Mithras in Scotland: a Mithraeum at Inveresk (East Lothian)

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SUPPLEMENTARY MATERIAL

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APPENDIX 1: FULL DESCRIPTION OF THE ALTARS

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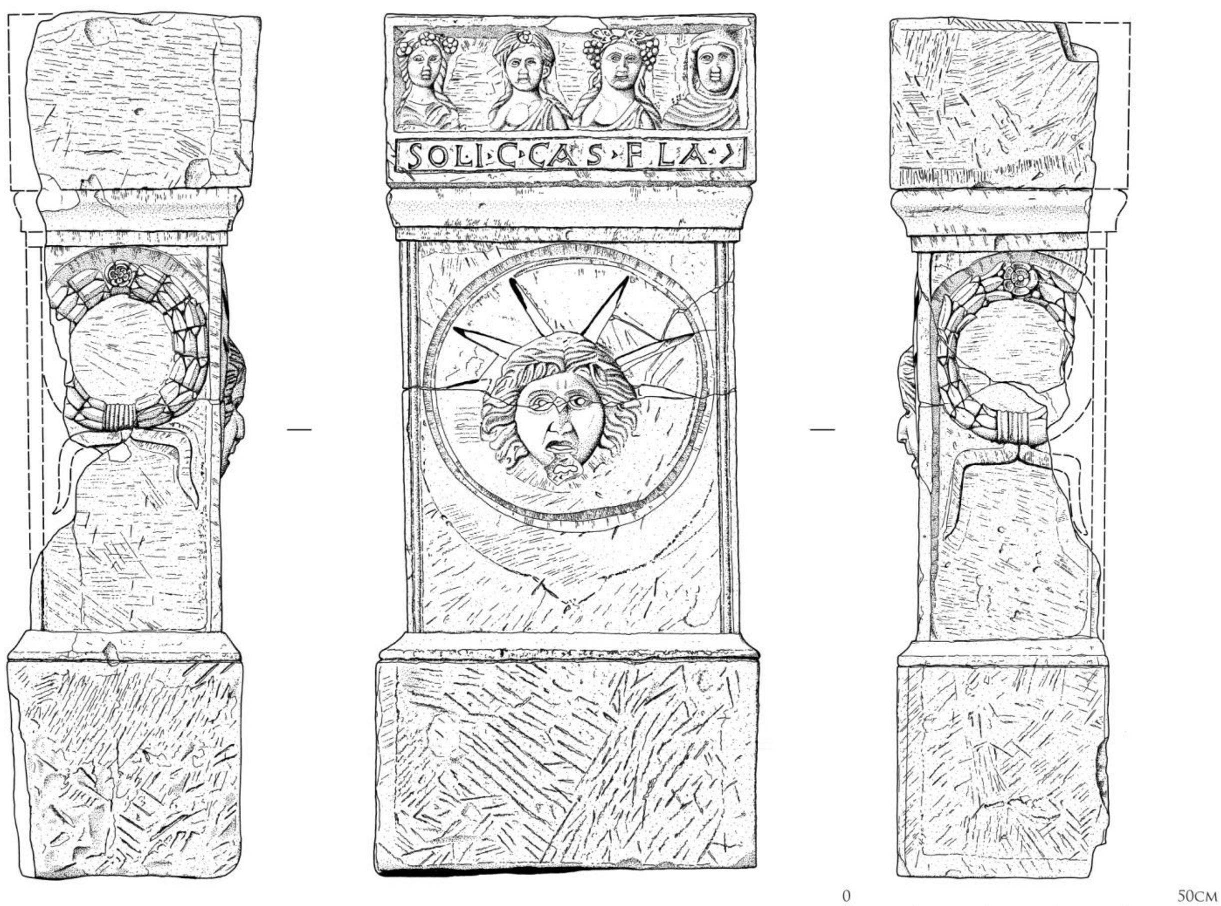
with a note on the lyre *by* GRAEME LAWSON

(Left and right are as viewed in the following descriptions, unless stated)

THE SOL ALTAR (FIGS 6–11; ONLINE FIG. 1)

The top of the rectangular capital is flat, with extensive punchmarks, and has a shallow focus, D 300 mm, 35 mm deep, the rear lost. A cylindrical socket lies in each of the rear corners, D 100 mm, depth 40–50 mm; these are now open to the rear, which has flaked off.



ONLINE FIG. 1. The Sol altar. (*Drawing: Alan Braby*)

The front has an upper sculpted panel and a lower inscribed one which reads SOLI.C.CAS.FLA.> within a rather irregular rectangular incised border. Red pigment survives on the lower edge. The field is markedly less smooth than the moulding below, with stray pick marks.

Within a recessed panel at the top are well-carved busts of the Four Seasons, arranged from left to right. All are female and frontal, with full lips, drilled dimples and closed mouths, the eyes having a drilled iris and incised pupil. The carvings are very competently done but the background is rather irregular, with horizontal chisel marks which are smoothed immediately around the figures. A chip from the centre of the upper border is likely to be damage caused by moving the altar into its final resting place (FIGS 9–10).

Spring has a garland in her hair: a wreath with three rosettes (with three or five petals and a central bud). Her hair is arranged in two long corkscrew tresses onto the shoulders. She wears a tunic with central V-fold. Summer wears a wreath with a central rosette; her hairstyle is similar to that of Spring. An off-the-shoulder dress exposes her right breast. Autumn wears a garland of ivy leaves (the fine detail defined by drilling) flanked by bunches of grapes. Her dress and hair match those of Summer. Winter is well wrapped-up, with her cloak pulled over her head, the folds going over her left shoulder.

A two-step moulding links capital and shaft, the lower a narrow rectangle, the upper *cyma reversa* (concavo-convex in profile with a deep roll at the top); it is very well finished. On the left side, a slight curved line near the front edge may be an initial false layout for the moulding.

A narrow flat outer and broad rounded inner pair of mouldings define the edge of the front panel (left, W 24–26 mm; right, W 25–28 mm). A few deeper pick marks from dressing still scar the surface. It bears the protruding head of Sol on a nimbus, but the layout has seen several incarnations. Below the final shallow V-groove defining the nimbus on the lower side is a concentric slightly irregular curved point-defined line. Below this, the surface is less well finished; within the line, the surface is either smooth or nearly so. There is no corresponding upper curve and the circle was clearly reset part way through layout. However, the final version is also poorly finished. At the top, the two ends of the circle overlap slightly rather than meeting, and at around 4 o'clock the initial pecked line lies inside the final line. The nimbus channel width is irregular, being narrow and steeper in some places, broad and shallow at others. The upper part of the nimbus is slightly convex.

In the centre of the nimbus is the god's face, its highest relief slightly less than that of the capital and base. It is carefully and competently carved and well finished, showing a youthful clean-shaven male face with furrowed brow, hooked nose and flowing locks centrally parted (the surviving nose is flat, in the same plane as the base and capital, the hook being lost in the fracture). The locks fringe the face down to the chin. Six triangular pierced rays, slightly irregularly spaced, run around the upper part of the head within the nimbus. The slightly open mouth is pierced and the pupils of the eyes are drilled. A chip of stone has removed the chin and pierced through to the hollow on the rear; a series of deliberate V-shaped toolmarks in this are keying points for a plaster repair (FIGS 8–9).

The shaft sides have a relief wreath with an arcade around the top, set within a recessed panel some 5 mm deep with flat borders (12–15 mm wide) and angled sides. The borders are carried as grooves to the moulding at the top of the shaft and an incised groove demarcates the slope from arcade to wreath. The upper surface is well finished and smoothed, while the recessed surface still bears toolmarks (FIG. 11).

On the left wreath, seven leaf-bundles on either side flank a rosette at the top, with central bud and three layers of leaves. The wreath is bound at the base with a broad central flat ribbon and three narrow V-sectioned turns to each side; the ends of the flat ribbon fall in a right angle and taper to a point. The wreath is carefully smoothed and the leaves very neatly formed, with central spine, slightly sinuous profile and upturned tip. The central rosette has five-leaf flowers around it.

The right wreath differs in detail. It has eight leaf-bundles per side rather than seven; the central rosette has two layers of leaves, the inner of three, the outer five. Its bud lacks a central dot. The ribbon is defined as three concave channels.

The rectangular base is finished to varying standards, with some areas well finished (especially the margins and upper edges), and others left part-worked (see Hill, Appendix 2). The left edge is notably less well finished than the right. Marking-out lines survive on the front base and both vertical edges of the right side; perhaps recessed panels were intended. A rather irregular V-groove demarcates the base from a rounded moulding at its junction with the shaft. This runs all round the shaft, with rolled edge, slight concave slope, and step into the shaft. It is not well finished: there are fine toolmarks all over and the boundary is irregular, expanding on the right side and forming an irregular convex bulge on the rear and a straight rather than concave slope on the sides.

On the rear of the altar, the base preserves its original form, roughly shaped by picking, with a crude chamfer into the shaft, the upper parts of which are sheared off (FIG. 7). Carved into the back of the shaft is a deep recess, at three levels: a flat base; sloping shelves on the sides, tapering from 15–35 mm; and a shelf at the front, immediately below the face, 40–50 mm wide. The interior is quite roughly finished, with the perforations from the face then more carefully finished. A deep radial channel on the inside represents a ray which was abandoned, pointing to changes in layout.

The presence of shelves on both the sides and front suggests modification of the arrangements. Perhaps the original deep socket was too deep for effective use of rear-lighting, and the upper shelf was rather narrow to hold a lamp safely. The step between the two levels, 27–41 mm, could take a wooden shelf, a suggestion supported by the smoothing of the toolmarks just above the side-shelf to accommodate a plank more easily.

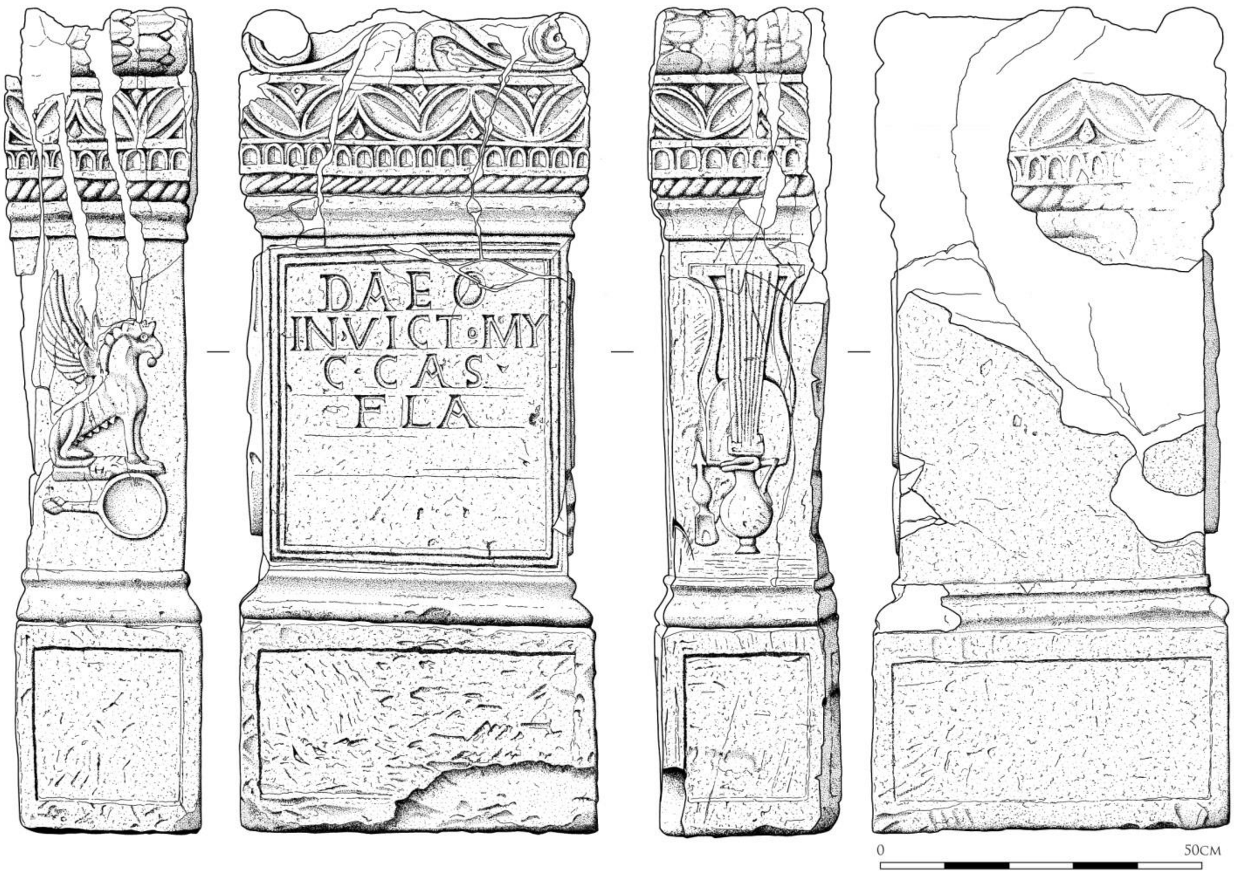
The mouth hollow shows an unusual feature. It is damaged where a chip was removed from the chin, but a vertical iron rod is carefully positioned in a D-shaped hollow behind the nostrils (visible length 13 mm, diameter 7 mm). It is unclear how it was fixed, but this hollow must have been designed to take something which looped round the rod — and presumably was suspended behind the mouth. Possible uses have been discussed in the main text.

Around 80 mm above the base of the shaft, a large part of the rear has sheared off, removing the rear edge of the shaft including the borders and part of the wreath. This lacks toolmarks and presumably represents accidental shearing, perhaps when the altar was moved.

The right side of the altar may have been intended to be more visible, as the base and wreath on this side are both better finished. As buried, this side was closely adjacent to the Mithras altar; it may be that the other side was concealed by an adjacent bench.

Dimensions (mm): H 1260, W 545, T 305–25. Base H 290–310; moulding 36–44; shaft H 570, W 480, T 245–65; top moulding H 44; capital H 250 by 545 by 340.

THE MITHRAS ALTAR (FIGS 12–15; ONLINE FIG. 2)



ONLINE FIG. 2. The Mithras altar (*Drawing: Alan Braby*)

The top, which is rather decayed, has a circular focus with well-finished flat rim and rather rough interior (FIG. 13a). It is flanked by cylindrical bolsters decorated with layers of overlapping leaf-scales; these were probably thunderbolts, but details are not clear, and the rear ends are badly damaged. The front ends of the bolsters have raised spiral ornament which leads into the margin of swelling triangular fields rising to a rounded top and dipping slightly where they meet, each containing a bird facing inwards. These elongated birds lean forward, with a heavy straight bill; the better-preserved right one has lines defining its wing (FIG. 13e). Their form identifies them as ravens or crows, the former more likely in a Mithraic context.

Below this, the capital is decorated on all four sides in three decorative bands. A flat ribbon separates the birds from a leaf frieze. Between pairs of oval leaves with sunken centres are central stalks (alternately pointing up and down) which split into two narrow V-sectioned leaves and a sub-triangular bud. The front and rear have three leaf-pairs, the sides two (one slightly compressed). A thin ribbon separates this from a row of arcades, each separately defined, with sunken centres. A further narrow ribbon separates this from an S-twist cable. The moulding at the boundary with the shaft is half-rounded with a concavity before a lower-relief rounded line.

On the front, three rounded strips define a slightly recessed inscribed face; their width varies from 30–35 mm. The inscribed face is 400 mm W by 435–45 mm H. The surface is well smoothed, especially at the base, where horizontal abrasion marks are visible. Traces of very faint marking-out lines imply it was laid out for a six-line inscription, not the four lines which were used; only the top of the sixth line was defined. The top line is 53 mm in height, the others 50 mm, with spacing between them of *c.* 12 mm.

The left side shows a griffin and patera in relief (FIGS 13c, 14). The eagle-griffin, seated on a raised ground-line, faces right; immediately below its beak a natural iron-rich inclusion has been left, probably deliberately, to form a pellet which it held. The eye has a raised pupil and dot iris. The crest comprises rounded triangles (the foremost is probably an ear); the raised wings have a single layer of nine flight feathers (the second one, badly damaged, is just visible). There is a row of five teats under the belly. The creature's anatomy is well defined, with powerful legs with expanded feline paws and clear musculature. The tail falls straight down and runs into the torch which the beast stands on. This has a rounded handle end and expands gradually from right to left; the tip is lost. There are hints of linear detailing on the poorly preserved surface. Below is a shallow patera with circular bowl, cylindrical handle (slightly mis-aligned) and worn ram-headed terminal.

The right side shows a version of a lyre, plectrum and jug (FIGS 13d, 15). The depiction of the lyre is unusually well planned and finely executed: symmetrical, with straight and evenly spaced strings arranged in an upward fan. Their number, seven, is significant, being the number which the Latin poets (following earlier Greek traditions) attributed to Terpander of Lesvos and his legendary improvements to the lyre (*cithara*). At their lower end there is a small angular feature representing the bridge, the structure that communicates the vibrations of the strings to the soundboard for amplification. The arms describe the tapering S-shapes common to many Roman depictions of lyres. The base of the sound box exhibits the straight edge and square corners typical of the larger wooden-bodied lyres at this time, or at least of Roman attempts at representing them in pictures. Below to the left is a plectrum with swollen shank tapering into a barbed arrow-like tip and spatulate base with flared sides. Slightly overlapping the base of the lyre is a round-bellied jug, facing left, with a simple horizontal channelled spout and an angled handle attached to the rim and belly. It sits on a flared foot, with a knob between the belly and the slightly damaged foot. The rear of the altar is plain, with the mouldings running around it.

A mirror image of the upper moulding links the shaft to the base. The rectangular base has a slightly recessed panel with flat borders set into each side, and is otherwise plain. The margins have been smoothed to allow it to stand better in the socket stone.

Dimensions (mm): overall H 1265, W 560, T 280. Base H 405; shaft H 517 by W 500 by T 245; capital H 350.

THE ALTAR BASE (FIG. 17)

Rectangular block, the rear and left side neatly dressed with heavy diagonal pick-dressing; the right side less well finished. The front was chisel-smoothed to remove most of the earlier dressing and create a nicer display face. The left margin is damaged but the right and base have smoothed margins. A rectangular recess was carved into the top, 285 by *c.* 575 mm. It is surrounded by a raised flat rim, *c.* 60 mm W, 45 mm H, badly damaged. The dimensions of the recess closely match the base of the Mithras altar. Overall dimensions 705 by 405 by 230 mm.

APPENDIX 2: TECHNICAL ASSESSMENT OF STONE-WORKING ON THE INVERESK ALTARS AND BASE

By PETER HILL

INTRODUCTION

The purpose of the work was to carry out a qualitative assessment of the two altars and altar base from Inveresk, by examining the tool marks and methods of working in order to gain technical information about the standards of workmanship. This appendix includes a full description of observations; conclusions can be found in the main report.

All three items were examined under cover in the Loanhead premises of AOC Archaeology Group. Some digital photographs are included in the report for reference and identification purposes, all taken using available light and thus not of the highest quality. It has been necessary to resort to strong sharpening of some images, and occasional perspective and colour correction, but no other alteration has been made.

DEFINITIONS/GLOSSARY

'Straight' means that the surface is straight within 1 mm in 300 mm. '**Round'** indicates a convex surface and '**hollow'** a concave surface, with the average or typical deviation given in millimetres. **'Square'** means an angle of 90 degrees within 1 mm in 300 mm. **'Over-square'** means an angle of greater than 90 degrees, **'under-square'** indicates an angle of less than 90 degrees, with the deviation given in millimetres. **'Approximately square'** is used where damage or the nature of the faces prevents accurate measurement but the balance of probability is that the faces are at or very nearly at right angles to each other. **'Range'** is the depth of the tool marks measured from the immediately adjacent surface. **'Blade'** means either chisel, axe or adze, and is used where it is not possible to discriminate. The width of the blade is given where this could be read. Reference to work with a **punch** should be read as including a pick, as it is not always possible to distinguish the work of the two tools; in general the heavier work will be more likely to have been carried out with a pick. **'Natural'** indicates an unworked surface which may be a natural bed or may be the result of splitting the stone as part of the quarrying or working process. **'Peck'**: a small depression in the surface resulting from the use of a punch at a high angle to the surface. **'Quirk'**: a V-shaped groove, either separating two parts of a moulding, or differentiating between two parts of a surface. **'Worked'** is used where some or all surfaces of the stone have been shaped with tools. **Measurements** of stone are always taken in the order width of face by depth by bed height. Both altars are face-bedded, and in the overall measurements the height is the middle figure. Measurements given for individual features are in the order as seen by the observer, that is with the height last. All measurements in the report should be treated as indicative rather than absolute.

STANDARDS

Judgement of the standard of workmanship is made by reference to what would be readily achievable by an averagely skilled, trained mason. Faces should be straight to within 1–2 mm in 300 mm, whether finished by punch or blade. Mouldings should be worked straight within 1–2 mm, having due regard to the difficulty of working some hollow mouldings. In addition to the accuracy of working, there should be good evidence of skill and care for the finished appearance.

The judgements may seem over-harsh, considering that the work may have been carried out by soldiers. Some at least would have been trained as stonemasons, however, and their work ought to be recognisable even though worked building stone in the north of the province was often less than high quality. However, occasional examples of good, professional workmanship are found, and it is important to be able to discriminate between these and the general run of work. The skilled Roman stone mason, soldier or civilian, was quite capable of this standard of work, even if it is rare to find it in Roman military work in northern Britain.

The writer is grateful to Dr Ciara Clarke and members of AOC staff for their hospitality and assistance.

THE SOL ALTAR (ONLINE FIGS 3–23)

The capital has a sunken panel with four bust in relief representing the Four Seasons, below which is an inscription over mouldings which return on both sides. The die has a pierced radiate head in relief, and the sides have relief carvings of laurel wreaths. The base has a moulding which returns on both sides. The back has large sinkings measuring overall 300 mm by 130 mm by 520 mm. The stone is broken into several pieces, with a complete break across the die.

The capital – front

The top is flat, worked entirely with a punch in pecks and short furrows 2–3 mm deep. It is generally straight, and square to the vertical fillets at either side of the front. The furrows are shorter and neater at the front than at the back on either side of the focus. The focus is a sub-circular sinking, *c.* 30 mm deep, all worked rather heavily with a punch, up to 5 mm deep (ONLINE FIG. 3). The outer edge of the focus has had some attention from a chisel but rather crudely done. At either side of the back is a sub-semi-circular sinking, all worked with a punch and rather crudely. As some stone has been lost from the back, it is not possible to tell the original form. The one on the left is *c.* 40 mm deep, that on the right *c.* 30 mm.

The sunken panel with the busts is 195 mm high, surrounded by flat fillets (ONLINE FIG. 4). The depth of the background is reasonably consistent at *c.* 20 mm, partly worked with both 40 mm and 30 mm chisels, especially noticeable between the two centre heads. The fillets around the panel descend to the background with chamfers which were worked with a chisel but are somewhat variable in quality. All the fillets are now damaged, but were probably originally more or less straight.

The busts are carefully modelled. The corners of the mouth on the second figure from the right were emphasised by a fine drill (ONLINE FIG. 5) and the same tool appears to have been used to indicate the pupils of the eyes of all except the left-hand figure where there is an inscribed circle instead. The headdress on the second figure from the right also shows the use of a drill.

Below the figures is an inscribed panel, bounded by V-cut lines, or quirks, to form fillets, 10 mm wide at the top and 15 mm at the bottom. This leaves an area for the inscription of 455 by 48 mm, although this is an approximate measurement as the quirks are very uneven (see ONLINE FIG. 6, where the bottom of the grooves is highlighted by a dotted line).

The letters are a slightly variable 33 mm high and are not especially well cut. Both letters A are very wide, the uprights on both letters L are not straight, the upper cross bar on letter F rises up, the left-hand lower serif on letter I droops down, and the first letter C is somewhat angular rather than round. Letters A have an angled cross-bar. All the letters are V-cut and rather weathered. The leaf stops are triangular. Around the centre there is a whiteness which might be pigment of some sort, or may be abrasion of the stone which has revealed more of its natural colour.

The lower fillet has chisel-marks, angled top left – bottom right (ONLINE FIG. 6), and has traces of red pigment along much of its length. All the quirks are unevenly cut and not at all straight, but the panel itself has been prepared very carefully. It is dead straight from side to side, although the surface was not smoothed. There is barely 1 mm deviation on the lower fillet. The inscribed panel is 3 mm under-square to the right-hand side of the capital and 3 mm over-square to the left-hand side. The inscribed panel returns in a horizontal fillet to a *cyma reversa* moulding (ONLINE FIG. 7). At the left-hand side the fillet is almost horizontal; towards the right-hand side it is more of a chamfer, and varies between 2–3 mm hollow and 2–3 mm round. It is of poor appearance. On the moulding itself the roll is almost straight, with a rise of almost 2 mm at one end of the hollow mould. Where the upper side of the roll goes into the fillet the finish is very bad, with pecks of up to 2 mm and it is not straight. The moulding is generally 2 mm under-square to the right-hand return, and 5 mm over-square to the left-hand return.

The capital – right-hand return

The right-hand return to the face of the capital was worked largely with a punch, in short furrows and pecks, up to 3 mm or more deep (ONLINE FIG. 8 left). The upper, front and lower margins were finished with a chisel and were originally probably about straight, although now weathered and damaged. The face is near straight in all directions and shows some care in working, although the appearance is not good.

The moulding on this return is somewhat less well worked than on the face, but is adequate, up to 2 mm hollow. Where the upper part of the roll turns in below the face in a quirk the junction is very crude and uneven (circled on ONLINE FIG. 8)

The capital – left-hand return

On the left-hand side the face is much the same as the right, except that the top margin is 2 mm round (ONLINE FIG. 8 right). However, the whole appearance is much neater and has been worked with more care. The left-hand return of the moulding has some damage towards the back but is generally better than that on the right-hand, and is straight to 1–2 mm round. There are traces of a chisel used in drafts along the moulding, leaving slight flats in places. The upper quirk is better than the right-hand one.

The die – front

The face of the die is largely occupied by large roundel, the upper part of which is domed, with a face in relief, and bounded on either side by a moulding consisting (working outwards) of a quirk, a roll, a quirk and a fillet (ONLINE FIG. 9). These mouldings were probably originally worked straight, but are now too weathered and damaged to measure accurately. Below the roundel the face of the die is finished rather heavily with a blade, 1–2mm deep, especially on the lower left-hand side, with many punch marks remaining (see ONLINE FIG. 13). The spandrels above the dome are worked with signs of a chisel; the right-hand side has been finished rather smoother than the left-hand. The upper half of the roundel is cut by six slots which are V-shaped in elevation to give the effect of rays (ONLINE FIGS 10–11). They are not set out symmetrically from side to side, and the centre two are more widely spread than the rest, perhaps by design. They are cut more or less perpendicularly through to the hollowed-out back of the stone. The roundel is surrounded by a circular broad V-cut groove some 25 mm wide but very variable in width. The groove to the left of the centre line curves down far too steeply, and has been corrected. The error may have been caused by the mason aiming for the point of the first ray which had not been cut long enough — and which was not corrected. The rays were cut with both a punch and a chisel, the latter leaving marks running top right to bottom left. Either the mason was left-handed or he was standing on the far side of the stone and leaning over. The latter is the more likely as there is no sign elsewhere on the altar of a left-handed mason. The surface of the rays has been carefully rubbed smooth, as if to emphasise them compared with the rest of the stone. The rays are domed.

The domed rays surround the head of the god, which is worked with a chisel and rubbed to a smooth, reasonably clean finish (ONLINE FIG. 12). The mouth and eyes have been pierced through to the hollow in the back of the stone. The chin has been damaged: this has also pierced through to the hollow, as the stone was particularly thin at this point. The hair is deeply modelled. The eye holes were probably initially cut with a drill of perhaps 5 mm diameter and then somewhat enlarged to give a less than circular shape. The left eye in particular is ovoid in form, stretching up to the top left. Part of the right eye is missing, lost in the break which runs through both eyes.

Below the circular groove is a very irregular crescent marked out by small punch pecks in an intermittent line (ONLINE FIG. 13). The surface of the crescent, especially on the left, has been finished with a chisel in a way which differentiates it from the general surface of the die below.

The die – left-hand return

The left-hand return of the die (ONLINE FIG. 14) is not only broken across the face but has lost a large piece from the back. The upper part has a laurel wreath carved in high relief. The top of the face was originally worked with a neatly chiselled horizontal draft, most of which was removed when a neatly chiselled circular chamfer was cut in as a surround to the top of the wreath. The chamfer is separated from the spandrels by a small and rather uneven quirk. At the front edge, the wreath is bounded by a raised fillet, the line of which is marked in the right-hand spandrel. There was also a raised fillet at the back of which only a small part remains at the base. The wreath is very neatly and cleanly worked, probably entirely with a chisel, although no tool marks remain. At the top, there is what resembles a Tudor rose. The ribbon depending from the wreath, and standing 2–3 mm above the general surface, still shows clear, neat chisel marks. The centre of the wreath is sunk and worked with a punch in fine pecks and a few indistinct chisel marks, to give a very neat effect. Below the wreath the stone has a sunk face bounded on the right by a raised fillet. The surface is worked partly with a blade but also shows some deep punch marks, and is overall *c.* 2 mm hollow in all directions. At the base the stone meets a 15 mm-wide fillet which is sometimes horizontal and sometimes more of a chamfer. At the bottom right-hand corner the sunken surface has a distinctly unfinished appearance (ONLINE FIG. 14 right).

The die – right-hand return

The setting of the laurel wreath is similar to that on the left, although the form of the wreath is somewhat more open in the arrangement of the leaves (ONLINE FIG. 15). There is again a 'Tudor rose' at the top. It is all badly damaged by the cracks and loss of stone, but was probably originally well worked. The sunken area in the centre of the wreath has more signs of the use of a chisel, but the punch marks remaining are more random and the overall appearance is not as good as that on the left-hand side. The surface is slightly domed, and the centre has some appearance of having been rubbed a little smoother than the rest. The ribbon shows chisel marks and has a clean appearance. The wreath has the ribbon hanging down to the left-hand side, or front, of the stone whereas on the left-hand return the ribbon hangs to the right, also the front of the stone. The wreaths are mirror images.

Below the ribbon the surface shows a number of punch furrows remaining, 2–3 mm deep, and is generally hollow. There are clear marks of a broad blade against the raised fillet on the front edge. This fillet has been damaged, but was generally rather roughly worked with a chisel. Against the lower moulding the surface is distinctly unfinished (ONLINE FIG. 15 right).

The base – front

As is common with Roman altars the base is the least-well-worked part. Immediately below the die there is a *cyma recta* moulding with a 15 mm-wide horizontal fillet above it. This has all suffered damage and is now very uneven, but was probably never very well or cleanly worked. The moulding is 2–3 mm hollow in places and the lower front of the roll is 2–3 mm hollow, very crudely worked. The mitres at the left- and right-hand ends do not meet the arris of the vertical fillets as they should (ONLINE FIG. 16).

Below the moulding, the surface is quite heavily worked but some effort has been put into it (ONLINE FIG. 17). The right-hand vertical margin is near straight and the left-hand was probably similar but is now damaged. There are numerous punch furrows and signs of a blade of indeterminate width, and overall it is straight to 2–3 mm hollow. The right-hand return, measured on the roll, is 5 mm under-square to the front, while the left-hand is 2 mm under-square.

The base – right-hand return

The *cyma recta* moulding is even worse than on the front and, in places, has almost a large chamfer rather than a hollow moulding (ONLINE FIG. 18). The quirk beneath the moulding is very poor and uneven. Below the moulding the surface is worked with a punch in pecks, 2 mm deep, with occasional signs of a blade. There is a chiselled margin at the front, but behind that the lower part of the face is sunk some 5 mm below a vertical line scribed as though to represent a fillet. This face is generally about square to the front.

The base – left-hand return

The *cyma recta* moulding is very poorly worked. The horizontal fillet was probably originally about straight, but not at all well finished (ONLINE FIG. 19). It has suffered damage, but was never good. Below the moulding the vertical margin at the front has been worked with a punch rather than a chisel, quite heavily in places with a very poor appearance. From the back of the stone the first 100 mm below the moulding has been worked with broad blade, top right to bottom left, very neatly done, varying between *c.* 2 mm round and straight, but it does not reach the front of the stone. Below the chiselled band, all work is with a punch in furrows, up to 7–8 mm deep, and in the lower left-hand corner the stone was never finished but rises by *c.* 8 mm. The top of this surface is 2 mm over-square to the front, while the lower part is not really measurable.

The bottom bed

This is worked with a mixture of a heavy punch, up to 10 mm deep, and a heavy blade in long strokes which might be from an adze. The right-hand side is more neatly worked than the rest and is about square to the front face, but the left-hand side is round by up to 20 mm (see ONLINE FIG. 17).

The back of the altar

The stone has been hollowed out in two successive square sinkings, using first a heavy punch and then a lighter one. The lower sinking is 200 mm deep, and the walls at the sides are between 60 and 90 mm on the left, 90 to 110 mm on the right. The upper sinking is deeper, leaving as little at 50 mm behind the left-hand side of the face and 60 mm on the right. This has left the stone rather fragile, and it is no surprise that is has broken (ONLINE FIGS 20–22).

Behind the domed, radiate crown the stone is 40 mm thick in the middle, 40 mm on the left-hand ray and 25 mm on the right-hand ray. In the area behind the mouth and chin of the face of the god is a third, sub-circular, sinking where the thickness of stone left is as little as 20 mm. The cut-through for the mouth is smaller on the back than the front. Above the mouth, as seen from the back, are two holes in the approximate position of the nostrils, but they are not cut right through (ONLINE FIG. 20). The stone above the eyes has been cut back on either side to give a thickness of *c.* 20 mm, leaving a broad rib in the centre (ONLINE FIG. 23).

The lower part of the back, below the sinkings, shows some loss of stone from the right-hand side, with the rest worked with a heavy punch up to 10 mm deep. The upper part of the back has been lost owing to the face bedding of the stone. The left-hand side of both base and capital is 320 mm from front to back so perhaps very little has been lost from there. The right-hand side of the cap is 300 mm deep, suggesting a loss of up to 20 mm. As already noted, there has been considerable loss in the middle of the left-hand return of the die.

ONLINE FIG. 3. The focus and top. (*Photo: P. Hill*)

ONLINE FIG. 4. The Four Seasons panel. (*Photo: P. Hill*)

ONLINE FIG. 5. Chisel marks between the two centre heads and drill holes at the corners of the mouth of the right-hand figure. (*Photo: P. Hill*)

ONLINE FIG. 6. Uneven quirks above and below the inscription. (*Photo: P. Hill*)

ONLINE FIG. 7. The moulding on the front below the capital. (*Photo: P. Hill*)

ONLINE FIG. 8. Right- (circled) and left-hand sides of the capital. (*Photo: P. Hill*)

ONLINE FIG. 9. The face of the die. (*From a laser scan by AOC Archaeology*)

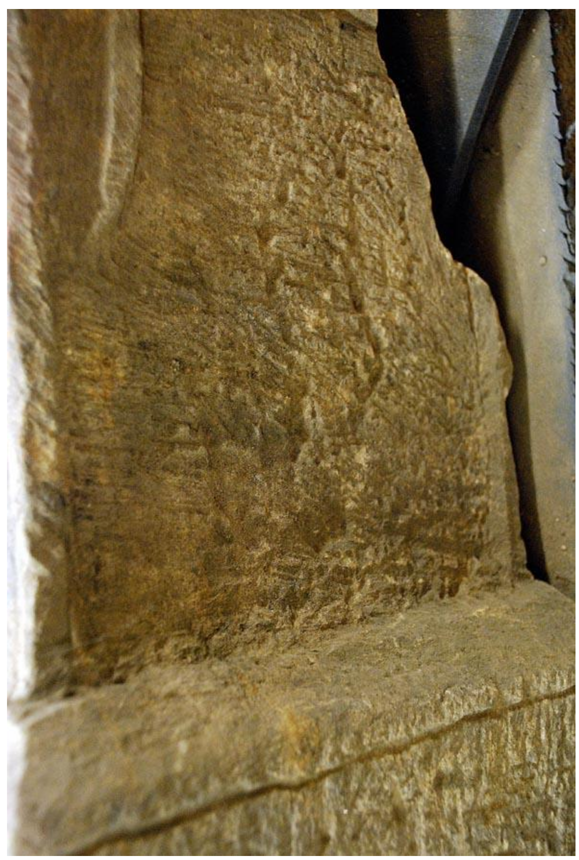
ONLINE FIG. 10. The doubled groove, and punch work to a ray. (*Photo: P. Hill*)

ONLINE FIG. 11. Chisel work to a ray. (*Photo: P. Hill*)

ONLINE FIG. 12. The head of the god, showing pierced eyes, mouth and damaged chin. (*Photo: P. Hill*)

ONLINE FIG. 13. The lower part of the face of the die, showing the crescent and the surface below it. (*Photo: P. Hill*)

ONLINE FIG. 14. Left-hand return of the die (left) and unfinished lower right-hand corner (right). (*Photo: P. Hill*)



ONLINE FIG. 15. Right-hand return of the die and unfinished lower part (right). (*Photo: P. Hill*)

ONLINE FIG. 16. Poorly worked *cyma recta* on the front of the base. (*Photo: P. Hill*)

ONLINE FIG. 17. The front face of the base and the bottom bed. (*Photo: P. Hill*)

ONLINE FIG. 18. Base, right-hand return.
(*Photo: P. Hill*)

ONLINE FIG. 19. Base, left-hand return.
(*Photo: P. Hill*)

ONLINE FIG. 20. Back, lower part. ‘Nostrils’ arrowed. (*Photo: P. Hill*)

ONLINE FIG. 21. Back, upper part. (*Photo: P. Hill*)

ONLINE FIG. 22. Back, upper part, showing thinness of stone. (*Photo: P. Hill*)

ONLINE FIG. 23. Back of the upper part of the head. (*Photo: P. Hill*)

THE MITHRAS ALTAR (ONLINE FIGS 24–38)

This altar is in a buff/white sandstone or gritstone, somewhat coarse in texture. It is now in several large pieces and a large number of small ones. The capital has two bolsters with a pediment between below which, and returning on both sides, are two bands of stylised foliage, a cable mould and a *cyma reversa* moulding. The face of the die carries an inscription in a sunken panel with mouldings all round, while the right and left returns show respectively a lyre and a griffin with a *patera* below. The front and both sides of the base carry a blank sunken panel below *cyma recta* mouldings (ONLINE FIGS 24–25).

The altar was not only badly fractured but was lying on its back in process of conservation in a narrow polythene tent which made access to some parts rather awkward. The broken parts were mostly separated from the main body when the altar was examined; those photographs showing large parts conjoined were kindly supplied by AOC. All these factors led to the assessment being somewhat limited in scope.

The capital

The part of the left-hand bolster which survives is 95 mm diameter, carved with laurel leaves. At the outer end is a spiral 15 mm-wide fillet which comes up and around the pediment. The fragmentary remains of the right-hand bolster confirm this pattern (ONLINE FIG. 26).

The focus was not examined. Between the pediment and the left-hand bolster the surface has been very heavily worked with a punch, leaving an untidy area which contrasts sharply with the much tidier working elsewhere (ONLINE FIG. 27).

The fillets which come from the spiral on the bolster ends form the upper surface of the pediment and from the top descend in two very wide fillets separated by a quirk. The pediment is straight across all the surfaces. Below the bolsters are very damaged and weathered remains of what was probably a flat fillet, somewhere between 15 and 20 mm wide. There is then a deep band of stylised foliage 85 mm high, then what may be either a 15 mm fillet or, more likely, a bead mould, and a 35 mm-high band of what appears to be vertical leaf forms. These rest on what may have been a continuous fillet, 15 mm wide, but which on the sides has the appearance of being divided with V notches; however, these may be the result of weathering or breaks in the stone. There is then a cable moulding, 30 mm high from quirk to quirk, which twists from bottom left to top right.

Measuring on the largest detached fragment (ONLINE FIG. 28), the fillet below the pediment is much weathered but straight, as is the bead below the upper foliage and the fillet above the cable mould. The latter is at maximum only 1–2 mm round, almost the best that could be expected on such a feature.

The capital then descends to the die by means of a *cyma reversa* moulding, which comes out at the base to form a second, smaller roll. The moulding is no more than 2 mm round at any point. There are small punch furrows on the upper edge of the top roll, where it turns into the cable mould, but they are generally shallow and the appearance is neat enough.

All the mouldings are returned on both sides of the altar, but in their present very fragmentary state assessment was very limited (ONLINE FIG. 29). The front is 10 mm under-square to the left-hand return which is itself straight from end to end, as well as could be established.

The die – face

The inscribed surface, which lies between raised mouldings on all sides, varies between 1–2 mm round and 1–2 mm hollow; this is to be expected for a sunken panel, which is more difficult to work than a simple plane surface. There is the occasional punch mark showing. The surface is weathered and may have been rubbed smooth before lettering.

The moulding consists of (working outwards) a small roll, a *cyma*, a quirk and a roll. Although heavily weathered, it seems that all were probably straight and well cut. At the bottom, the only part measurable, the mouldings are 2 mm over-square to the left-hand side and virtually square to the right-hand side.

On the inscription itself, which takes up only the upper half of the die, traces of scribed marking-out lines survive above and below line 2, above line 3, and above and below line 4. These are arrowed in ONLINE FIGS 30 and 31. All letters are 50 mm high.

The lettering is a little uneven in quality, something which is partly due to the coarse nature of the stone. On line 2 letter M has been cut with upright strokes, but the left-hand one has a distinct wiggle in it, probably due to a large grit which was in the way. This stroke also fails to meet the first diagonal stroke due to an error in cutting the latter, while the junction is bridged by the serif. Letter T has a rather wide and tapering vertical stroke (see ONLINE FIG. 31).

The three occurrences of letter C are all somewhat uneven in their curves and rather narrow, while the upper curve of letter D is a little flattened. The horizontal stroke of letter L droops and the right-hand stroke of Y cuts into the moulding. All letters A have an angled cross-bar. There is a triangular leaf stop after the first letter on line 3 and at the end of the line.

The die – right-hand return

This carries a relief carving of a lyre and plectrum, standing almost 15 mm above the background. It is very neatly and carefully executed, but the right-hand arm (lower arm in ONLINE FIG. 32) of the frame is almost touching the right-hand one of the seven strings while there is a clear gap on the left-hand side. But this does not really detract from a fine piece of work. The only tool marks visible are those of a fine punch.

The background is less good. There are signs of a very irregular chiselled margin, now largely lost, against the front face, with most of the rest worked with a punch to a not very even surface. Below the foot of the lyre there are clear horizontal marks of a broad blade. The mouldings around the front of the die do not appear on this face.

The die – left-hand return

This is largely taken up with a relief carving of a griffin (ONLINE FIG. 33). It stands as much as 25 mm above the surface. The carving is very carefully and skilfully executed, all worked with fine pecks. It faces the front of the altar. Below the figure is a torch and a bowl, the handle of which does not lie on the diameter of the vessel (ONLINE FIG. 34). The background is all worked with a fine punch and, although now very weathered, appears to have been very neatly worked. No sign could be seen of a chiselled margin on the front edge.

The base – front

Below the die is a small roll and *cyma recta* moulding which return to both sides, repeating the upper mould in reverse. The small roll is weathered and damaged. The hollow mould is up to 2 mm round with signs of working with a chisel; the lower roll is straight. Measuring from the lower roll, this face is 3 mm over-square to both left- and right-hand returns, but half of this figure is probably due to weathering.

The is a rectangular sunken panel 3 mm deep surrounded by wide, flat fillets 40 mm wide at the top, 30 mm on the left, 35 mm on the right and 50 mm along the bottom, where the lower right-hand corner is lost (ONLINE FIG. 35). The upper, right-hand, and left-hand fillets were probably originally straight and generally clean, but are now weathered and damaged and the left-hand fillet has two or three deep punch marks. The lower fillet has several punch furrows 2–3 mm deep on the left, and is too fragmentary to check further. The sunken panel has pecks and furrows up to 3–4 mm deep, and is generally between 2–3 mm round and 2 mm hollow.

The base – left-hand return

Although now weathered and damaged, the hollow moulding is very good, 1–2 mm hollow; the rest is not measurable (ONLINE FIG. 36). Below the moulding is a rectangular sunk panel as on the front. The upper fillet is 40 mm wide, the right and left fillets are 25–7 mm, and the lower fillet 45 mm. The upper fillet has occasional furrows 2 mm deep and is 2 mm hollow, but is otherwise quite cleanly worked, as are the right and left fillets which are 1–2 mm round and straight respectively. What is left of the lower fillet has a number of furrows and pecks, 2–3 mm deep, and is not of such good appearance but is generally straight. The sunken die is worked with pecks and short furrows and is of reasonably neat appearance. It is 1–2 mm round.

The base – right-hand return

The mouldings, returning from the front face, are virtually all dead straight, although now much weathered (ONLINE FIG. 37). There is the same rectangular sunk panel surrounded by broad fillets, 40 mm at the top, 35 mm at the front and 25 mm at the back, and 55 mm at the base. The lower part of the front fillet has been lost. The upper fillet was worked in part with vertical blade strokes, and is *c.* 2 mm round. The front fillet has preserved only occasional punch marks, and what is left of it is 2 mm hollow. The back fillet is about straight as is the lower fillet, but the latter undulates some 2 mm and has vertical blade marks. All the fillets have a generally neater appearance than on the left-hand return or the front. The sunken die shows some traces of a blade as well as a number of punch furrows and pecks, 2 mm deep, and is overall some 2–3 mm round.

The bottom bed

This was worked with a heavy punch, with furrows up to 3–4 mm deep on the left-hand side. Overall it is some 15 mm hollow, but the margins are more or less straight and in the same plane. The base measures 560 mm wide by 280 mm deep.

The back

A photograph supplied by Dr Clarke of AOC shows that the two bands of foliage decoration, and possibly the cable moulding, continue around the back of the altar, as does the *cyma recta* above the base (ONLINE FIG. 38). The photograph also appears to show that there is a sunken panel on the base to match those on the front and sides. It is not possible to judge the quality of the workmanship from this.

ONLINE FIG. 24. Front view of the complete altar. (*Photo: Ciara Clarke/AOC*)

ONLINE FIG. 25. The altar as examined. (*Photo: P. Hill*)

ONLINE FIG. 26. Spiral on right-hand bolster. (*Photo: P. Hill*)

ONLINE FIG. 27. Between the pediment and the left-hand bolster. (*Photo: P. Hill*)

ONLINE FIG. 28. The largest fragment of the front of the capital. (*Photo: P. Hill*)

ONLINE FIG. 29. Capital, left-hand return. (*Photo: P. Hill*)

ONLINE FIG. 30. The inscription. (*Photo: P. Hill*)

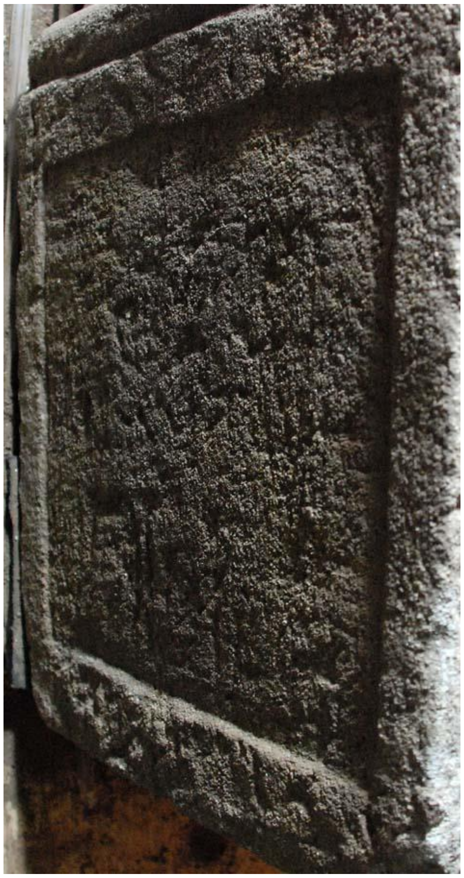
ONLINE FIG. 31. Right-hand end of line 2. (*Photo: P. Hill*)

ONLINE FIG. 32. Lyre and plectrum, right-hand return of die. This view also shows the badly fractured state of the altar. (*Photo: Ciara Clarke/AOC*)

ONLINE FIG. 33. Left-hand side of the die, with griffin. (*Photo: P. Hill*)

ONLINE FIG. 34. Left-hand side of die, bowl. (*Photo: P. Hill*)

ONLINE FIG. 35. The base, front face. (*Photo: P. Hill*)



ONLINE FIG. 36. Base, left-hand return.

ONLINE FIG. 37. Base, right-hand return.

(*Photos: P. Hill*)

ONLINE FIG. 38. The back of the altar. (*Photo: Ciara Clarke/AOC*)

THE ALTAR BASE (ONLINE FIGS 39–45)

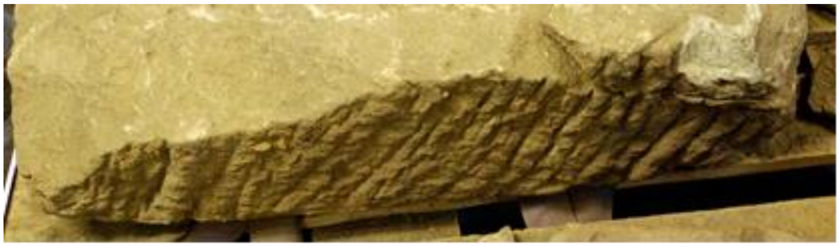
This takes the form of a roughly worked rectangular block of buff/white sandstone with a rectangular sinking in the upper surface. The upstand left by the sinking has all broken away, but enough pieces survive to show that the depth was around 45 mm, although the upper surface of the upstand also appears to have been lost (ONLINE FIG. 39). One end of the block has cracked through and become detached.

The bottom bed was not available to study, but by feel it is a natural bed. The sides of the block are heavily worked with a punch over most of the surface (ONLINE FIGS 40–41); one exception is the upper part where some of the detached upstand survives. Here, the upper 100 mm including the upstand was finished with a blade, probably a chisel, and was clearly designed to be seen (ONLINE FIGS 42–43). It is on this basis that the two long sides of the block are designated front and back. The width of the blade could not be determined, but it was a broad one, with strokes running top left to bottom right (ONLINE FIGS 44–45).

Most of the right-hand end of the base of the sinking is worked chiefly with a punch leaving 5 mm-deep pecks and 2–3 mm deep furrows, with faint signs of a blade in places. The left-hand end, which includes the detached piece shows many chisel marks, circled on ONLINE FIG. 44. Overall the base is reasonably straight.

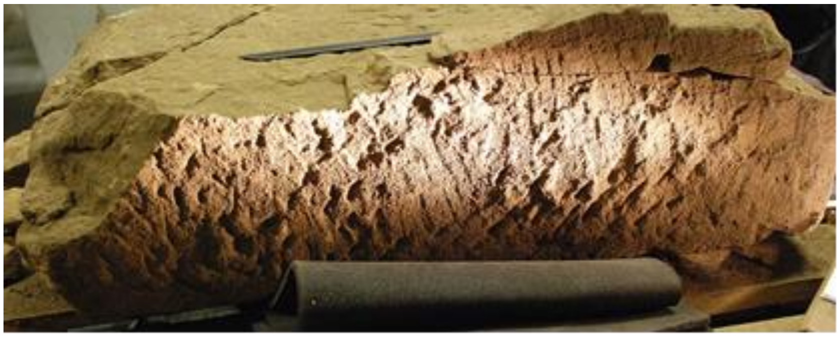
The inner face of the upstand, which is *c.* 60 mm thick and near straight, was worked with a punch, by a left-handed mason standing over it at the front, or by a right-handed mason reaching across the stone from the back (ONLINE FIG. 45). The latter is much more likely as no other sign of left-handed work has been seen. A little has probably been lost from the top of the upstand while the sinking may have been as much as 50 mm deep. Judging from the small fragments of upstand still in place, and from the marks where other pieces have broken off, the size of the sinking was probably 570 mm by 285 mm.

ONLINE FIG. 39. The altar base top, from the back. (*Photo: P. Hill*)



ONLINE FIG. 40. The altar base: back, with heavy punch marks. (*Photo: P. Hill*)

ONLINE FIG. 41. End, with heavy punch marks. (*Photo: P. Hill*)



ONLINE FIG. 42. Front, showing marks of a broad chisel. (*Photo: P. Hill*)


ONLINE FIG. 43. Close view of the chisel marks on part of the front face. (*Photo: P. Hill*)


ONLINE FIG. 44. Top from the front. (*Photo: P. Hill*)


ONLINE FIG. 45. The detached fragments of upstand, showing punch marks. (*Photo: P. Hill*)

APPENDIX 3: LITHOLOGICAL DESCRIPTIONS AND PROVENANCE OF THE INVERESK ALTARS AND OTHER ROMAN SCULPTURE AND INSCRIPTIONS FROM INVERESK

By FIONA M^c^GIBBON

OBJECTIVES

The two sandstone altars and an altar base from Inveresk were examined macroscopically and representative thin sections of each were examined microscopically, allowing detailed lithological description. Twenty-one other Roman sandstone artefacts from Inveresk in the collections of National Museums Scotland were also investigated macroscopically to allow comparison of the altars with an assemblage of contemporary objects from the same area. A brief desk-based consideration of potential local sandstone sources lead to investigation of several local outcrops, mainly in the intertidal exposures at Joppa, just east of Inveresk.

INTRODUCTION

Provenancing studies on stone artefacts are limited in their success by the lithology of the objects being investigated. The type of information that different rock types reveal is a major factor influencing their provenancing potential. Igneous rocks are most useful, especially when diagnostic geochemical data are available. Such data can uniquely characterise the object and its source if a comparative geochemical database is available, as with the Stonehenge Bluestones.[1] Sedimentary rocks are harder to provenance due to their common occurrence and their heterogeneity at any one geological location. Sandstone is a very common sedimentary rock type and investigations limited to comparison by visual appearance alone have limited potential in uniting artefacts with specific source locations.

SANDSTONE PETROGRAPHY

Sandstones are all those medium-grained sedimentary rocks that comprise more than 50 per cent sand size material with a mean grain size of 0.063–2 mm.[2] They are divided by composition, with the most important subgroup being siliciclastic sandstones which are typical of material derived ultimately from weathering of continental rocks (i.e. terrigenous settings). They are typically comprised of quartz and/or clay minerals sometimes with rock fragments (pebbles). They result from transport of these erosional products over varying distances and conditions before deposition in various environments as detrital grains and precipitates. Long-distance transport removes the physically and chemically less durable materials and rounds the quartz grains, such that sandstones that are deposited far from their original erosional source are dominated by resistant rounded quartz grains and are considered mineralogically *mature*. By contrast sandstones containing a large component of easily weathered feldspar are

[1] Williams-Thorpe and Thorpe 1992.
[2] Stow 2005.

mineralogically *immature* and result from rapid deposition near their source, in alluvial fans or fluvial or lacustrine environments.

Sandstones are generally porous and permeable but these aspects can be reduced by compaction and secondary cementation or other post-depositional processes. Equally, primary matrix material or later cements can be leached from sandstones due to their permeability. Leaching and dissolution of soluble components by plant roots, for example, can leave a poorly cemented, bleached sandstone type called a ganister. These are common in the Carboniferous Period Coal Measures successions of Europe, where they were originally deposited in deltaic sequences that were capped by vegetation. These leached sandstones occur beneath coal seams and directly beneath seatearths that are considered to be fossil soils, from which contemporary plant roots penetrated into the sandy layers below, leading to leaching by organic acids.[3] These sandstones are typically massive and can be kaolinite rich if leaching was excessive. They tend to be characterised by the presence of fossil rootlets and often have secondary iron minerals in the form of siderite (an iron carbonate) nodules. Sandstones of this type owe their appearance both to the deposition of the original sediment in a fluvial setting followed by this post-depositional modification by plant roots which makes them quite distinct from other sandstone types.

Sandstones can be cemented by quartz, clay or iron oxides of various types.[4] Many cements are produced by the chemical breakdown of unstable minerals such as feldspar or various iron-bearing minerals. These cements can be derived *in situ*, or can come from external sources such as deeper parts of the formation where temperature and pressure may aid in the dissolution or breakdown of material. Clay can form a primary matrix (i.e. deposited at the same time as the sand grains) or a secondary cement, delivered by pore water moving through the sediment after deposition. Illite and kaolinite are the most common clay cements and are bright white but easily stained by other materials such as iron. Iron oxide is a common cement, especially in arid continental depositional settings. Sandstones are easily reddened by iron oxide even when iron is present at less than one per cent concentration. Iron oxide introduced in solution will precipitate out in pore spaces as various hydrated iron oxides such as limonite which is a yellowish brown, ochre colour. This would form an intergrain cement that may slowly be turned red by oxidation depending on the later diagenetic history of the sediment. So sandstones can be a variety of colours both as a result of original depositional features but also by localised post-depositional modification and many sandstone exposures show colour variability on many scales as a result. This means that sandstones can vary in appearance on many scales such that general appearance is not always a useful provenancing tool. However, consideration of primary features such as grain shapes and size range, as well as larger-scale features such as bed-forms, reveals much about the depositional environment of the sandstone leading to a characterisation that may allow it to be linked to specific formations in the area.

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[3] Tucker 2011.
[4] Sheldon *et al*. 2010.

METHOD

Artefacts were examined with a standard 10x hand lens in most instances. This was carried out in various lighting conditions depending on location. Arefacts were sometime in awkward or poorly lit settings. By contrast, fragments of some artefacts (when available) were examined at much higher magnification with a binocular microscope and filtered light. The two Inveresk altars and the altar base found with them were examined by thin section with a petrographic microscope in plane- and cross-polarised light. A standard sedimentological grain-size chart was used to establish the grain size of quartz for a grain-size classification of each object. Some colour classifications were attempted using a Munsell soil colour chart, but the strong discolouration by soil on some artefacts from burial and the variable nature of the colour of some sandstones meant that detailed colour comparisons were not justified. Detailed descriptions follow and are summarised in Table 2.

MACROSCOPIC DESCRIPTIONS

The Mithras altar

This lithology is extremely brittle and clearly has very different physical properties to the Sol altar lithology, which is far more robust. Grain size is coarse, averaging 0.500–0.750 mm, but with numerous grains up to 2 mm in size (see ONLINE FIG. 46). Grain shapes are noticeably angular. The overall colour of the sandstone is bleached white which results from the matrix clay; this is sometimes in euhedral (block-like) shapes, suggesting *in-situ* breakdown of potassium feldspar. The clay percentage is large and in places the sandstone appears matrix-supported (i.e. grains suspended in matrix rather than in grain contact) but this will be discussed further in considering the thin section. Very abundant muscovite flakes are clear rather than golden. Pinkish red vitreous grains are thought to be detrital grains of garnet which may be a useful diagnostic feature. The rock type is extremely friable; the poorly cemented grains can be easily rubbed off.

The sandstone is very poorly sorted with very variable grain size and many angular grains of 1.5–2.0 mm, usually of white milky quartz (or perhaps quartzite) fragments. One fragment was 6 mm in length. These coarser grains are concentrated in patches or horizons which probably represent depositional layering or bedding. Bedding is otherwise hard to discern, but appears to be parallel to the front and back of the altar, this being most clearly visible by the griffin-like carving on the side.

The front of the slab has several blob-like inclusions which are 1–2 cm in width and stand slightly proud of the worked surface. Although they initially appear like lithic clasts, closer inspection shows them to be patches of iron staining perhaps representing secondary formation of iron nodules, most likely siderite. Careful examination shows the matrix quartz grains within these areas to be identical to those outside them, suggesting an overprinting of secondary iron mineralization over the matrix sandstone (ONLINE FIG. 47). Other than this, there is little to observe, the material being remarkably homogeneous.

The altar base

A detached fragment of this stone was examined by binocular microscope at 10x magnification with filtered light. This is a coarse sandstone but has the same constituent minerals of quartz and detrital muscovite (and minor biotite) in a bleached white clay matrix with variable secondary iron staining as that seen in the Mithras altar. The average grain size of quartz is *c.* 1 mm but the sandstone is poorly sorted and grains of 2 mm are common. Grain shapes are notably angular and the rock has an open porosity. Lithic clasts of a fine-grained dark rock are present. The matrix is a bleached white clay, most likely kaolinite. Block-like shapes of this white clay are present, suggesting *in-situ* alteration of potassium feldspar grains to kaolinite. The presence of altered feldspar suggests a mineralogically immature sandstone, or subarkose. Examination of the whole slab (which is heavily coloured by surface staining by soil) reveals little, the rock being very homogeneous and lacking obvious bedding. The upper lipped edge of the block is reddened in contrast to the rest of the block, perhaps suggesting the presence of an applied hematite pigment in this area.

The Sol altar

The detached fragment of this altar from which the thin section was taken was examined with a binocular microscope at 10x magnification with filtered light. Grain size of quartz is 0.187–0.250 mm, meaning this sandstone is fine grained and well sorted, in marked contrast to the Mithras altar and the altar base. Sand grain shapes are sub-rounded to rounded. Detrital muscovite mica is present at larger size, 0.375 mm. The matrix appears to be white clay with regularly spaced (at 1 mm spacing) dots of iron oxide staining giving the sandstone a speckled appearance.

The interior of this sample was examined on the saw cut from which the piece for thin sectioning was removed (ONLINE FIG. 48). This allows the colour of the material to be assessed. It is peach coloured, Munsell 10R 8/2-8/3, officially described as pinkish white. The discolouration at the edge of the sample is evident indicating peripheral leaching and oxidation as well as discolouration by soil, most likely during burial. This effect only penetrates a few millimetres into the sample. Examination of the trimmed off, stained, thin section sample shows that the stain added as part of the thin section preparation has only permeated *c.* 1 mm into the sample, showing it to have low permeability.

Examination of the whole altar was carried out in order to look for larger-scale features such as bedforms and sedimentary structures. The slab of stone is remarkably homogeneous with no evidence of clasts of any sort, fossils or larger-scale features. Bedding is evident and is parallel to the long direction of the slab such that the front and back vertical faces of the altar represent bedding planes. The stone is still strongly coloured by soil which hampers examination and only broken surfaces were examined in detail. The broken surface on the left-hand side of the altar shows leisegang rings of secondary iron staining, ochre in colour, suggesting a hydrated iron oxide such as limonite. There is a strong colour difference underneath the inscription on the front of the altar. Below the letter C after SOL there is a depression filled with a granular brick red material presumed to be hematite. This differs markedly to the colour of the soil and to the secondary iron staining which is a feature of the rock type, and suggests the application of a hematite pigment on the front of the altar (see Siddall, Appendix 4).

Examination of the back of the stone, behind the carving of the face with radiating ray perforations, reveals a strong difference in colour. Behind the nose, the sandstone is very oxidised and this appears to be localised to this part of the altar. This supports the suggestion that a candle or lamp may have been placed here to illuminate the altar from behind. The heat would have oxidised the iron in the sandstone, changing its hue to the darker red-brown colour noted and suggests use of the altar in this way before burial.

Building stone (find # 017)

The lithology of this artefact differs markedly from the altars and the altar base. It is much finer grained (grain size could not be assessed by hand lens) and it displays clear ripple cross-lamination. The biggest contrast is in the colour of this sandstone, which is strongly iron-stained with colour varying from brick red to ochre, suggesting limonite. The smoothed scrapes on the artefact suggest a high clay content.

OTHER SCULPTURE AND INSCRIPTIONS FROM INVERESK

These were examined with a 10x hand lens with a strong directed light source. Fragments of the Sol and Mithras altars were borrowed for direct visual comparison with these other artefacts. Descriptions are presented below and summarised in Table 2.

Q.L.1977.13 – Procurator's altar

This altar was examined on display at the National Museum of Scotland with a torch and hand lens. Two small drill cores (10.5 cm long and 12 mm wide) were created when the artefact was originally mounted for display and these cores were examined at high magnification with a binocular microscope.

The cores are described first (see ONLINE FIG. 49). They show a strong and sharp difference in colour from the exterior of the artefact to the interior, indicating that the exterior colour is strongly affected by soil. The exterior is an ochre colour and the interior is a bright white for which there was no Munsell colour match. The cores are of sandstone of medium grain size with an average of 0.375 mm but with some grains larger than 2 mm present. The quartz grains are glassy and very clear, typical of water-transported quartz. Grain shapes are sub-rounded. Muscovite is present as a detrital grain of thin clear sheets up to 1 mm width; minor biotite mica was also noted. The matrix of the sandstone is a white clay, most likely kaolinite, and it is sometimes identifiable in blocky shapes mimicking feldspar from which it has been derived by *in-situ* decay. The sandstone shows an open porosity. There are spaced spots of iron oxide which is ochre-coloured, staining the clay matrix. A single grain of a metallic mineral was noted, with cubic shape and a blue-grey iridescence. This was reminiscent of galena but cannot be positively identified by this method. A common accessory grain is reddish pink and vitreous. It was seen in a range of grain sizes, 0.250 mm, 1 mm, 1.5 mm. The grains are elongate and are typically longer than the average grain size of quartz in the sandstone, and more angular. This is thought to be garnet. A blue-grey clast with strong cleavage was also seen in the sandstone; it was found to be very soft and is thought to be chlorite.

This sandstone is typical of those found in terrigenous depositional environments where they are derived by weathering of continental rocks followed by transport in river systems. The presence of heavy mineral grains such as garnet suggests a contribution from weathering and erosion of metamorphic source rocks as well as granitic rocks which would supply the bulk of the grains seen, i.e the quartz, mica, feldspar (and its decay product kaolinite). Such sandstones are typical of Carboniferous Period deltaic sandstones.

A direct comparison of these cores with a sample of the Mithras altar was carried out. The Mithras sandstone has a greater clay content and is whiter as a result. Washing the Mithras fragment to remove surface clay dust reveals that it does have some spaced iron-oxide spots similar to those seen in the Procurator stone cores. The two bear many other similarities, being of similar grain size and displaying similar grain shapes. The mineralogy is also similar with the minor grains noted being muscovite and minor biotite, and most significantly the pinkish red vitreous grains presumed to be garnet, which is present in both. The Mithras sample also revealed a soft blue-grey clast with cleavage similar to that noted in the Procurator stone core and thought to be chlorite. The two sandstones also share in common the presence of the kaolinite blocks pseudomorphing feldspar. The Mithras sandstone displays a slightly more limited grain-size range suggesting better sorting, but this does not imply a distinct source and the subtle differences could easily be those expected within a single formation or even bed at outcrop reflecting depositional current variation.

Examination of the Procurator stone itself in the gallery added little to this as it was only carried out with hand lens and the stone was discovered to be coated in some sort of protective material. A chip on the right-hand side shows a grain size of 0.375 mm and shows the speckled spaced iron oxide staining noted in the cores. There were no macroscopic features to note, such as bedding or lamination. The sandstone is remarkably homogeneous in each dimension and it is clear that a slab of uniform material has been intentionally selected.

FV 31 Pine cone from Midfield Mains, Inveresk

This object (ONLINE FIG. 50) was removed from display and thoroughly examined with a hand lens in natural light. It is made from well-sorted ferruginous sandstone that shows very clear lamellar bedding, which runs vertically through the object. The Munsell colour varied from 10R 4/4 to 10R 5/6 depending on surface staining. This colour is a reddish brown typical of hematite that strongly colours this sandstone, making it much redder than other artefacts examined. The sandstone is very well sorted (with very little grain size variation) and grain size is 0.375 mm, making it medium-grained. It shows a sugary texture and an open porosity and displays a twinkle that results from grain-point recrystallisation of quartz. Detrital muscovite is common and is usually of similar grain size to the quartz grains but can be larger. The fine bedding that is very noticeable is accentuated by iron oxide that is not completely uniform in its distribution but concentrated on particular, very thinly spaced bedding planes. This is most likely due to a cessation of sedimentation and accumulation of iron oxide by exposure between depositional episodes and so most likely represents an original depositional feature. This indicates that the iron oxide is a primary depositional component, not a secondary introduced material and as such suggests an arid depositional environment. There are no inclusions or other heterogeneities, the sandstone being remarkably homogeneous. It is also robust and well cemented and is an excellent choice of material for such a fine carved object. This sandstone is unlike local Carboniferous sandstones and is more typical of Devonian sandstone which is available within the Midland Valley, or Permian age desert sandstones which are not.

X.FV 67 Fragment of tombstone from Carberry, near Inveresk

This object was examined in storage on a pallet on the floor with fairly poor lighting conditions using a torch and hand lens. It should be noted that the object has so much remaining soil cover (with adhering rootlets) and staining that it was impossible to determine the colour of the unsoiled stone. Where recent scratches through the soil cover offered small glimpses of the sandstone it was seen to show an ochrous colour of limonite (hydrated iron oxide). The sandstone is medium to coarse grained with a grain size variation of 0.375–1.000 mm, an average of *c.* 0.500 mm. Some larger sand grains were as large as 2 mm. Detrital flakes of muscovite were abundant and are sometimes very large. The sandstone twinkles, perhaps suggesting grain point recrystallisation between quartz grains. Grain shapes are sub-rounded. Bedding was not at all obvious in this large slab which, despite its size, is remarkably homogeneous in every dimension with the exception of a few large inclusions. At the top vertical face of the stone there are two inclusions. One is thin but wedge-shaped with surface striations and has a strong limonite colour. This is thought to be a rip-up clast of a ferruginous mud incorporated into the sandstone at time of deposition. To the right of this is a black, flaky, angular, flat fragment which shows brittle fracture. This is carbonaceous organic matter, most likely a plant fragment incorporated at time of deposition. On the front surface of the slab there are several pits which are presumed to be where inclusions like those described have fallen out, or been weathered out. Some feldspar fragments of 1.5–2 mm were noted in a gritty horizon. These features are typical of the Carboniferous age sandstones of the area which result from a deltaic depositional environment, the evidence being the inclusion of terrigenous erosional components and organic matter.

Q.L.1977.14 Column portion

This fragment is comprised of medium-grained (average 0.375 mm, 0.250–0.375 mm range) sandstone with muscovite flakes (usually of similar grain size) and rectangular chalky white blocks that are thought to be kaolinitized feldspar. The artefact is strongly coloured by soil but a broken area reveals the presence of iron of ochrous colour, showing leisegang rings as a result of its secondary nature. Iron is also present as speckles within the sandstone with a very regular spacing. A carbonaceous inclusion (2 cm in length) with wispy shape suggests inclusion of organic matter at the time of deposition and carbonaceous particles of similar size to the sand is also noted. An irregularly shaped elongate cavity (2 cm by 5 cm) suggests the dissolution of a clay clast (rip-up clast) after deposition.

Q.L.1977.15 Column portion

Strongly coloured by soil coating. Well-sorted, medium-grained sandstone of grain size 0.375 mm. Grain shapes are hard to discern given the fine grain size, but appear sub-rounded rather than angular. Muscovite is common and flakes are often larger than the quartz grains, giving the rock a twinkle. It has a sugary texture with some open porosity. There is a white matrix material. This sandstone has a patchy distribution of iron in a peach to beige colour, spaced at 1.5–2.0 mm intervals giving a speckled appearance. There is no obvious bedding or layering, suggesting a very homogeneous material. A carbonaceous clast (10 mm by 5 mm) was noted; brittle, black and flake like. Closer inspection revealed many smaller carbonaceous specks of less than 1 mm size.

This lithology has some common features to that of the Sol altar although the latter is finer grained and displays clear bedding which this column portion does not. The Sol sandstone is also darker and the speckled appearance it displays is of finer, more closely spaced iron specks. The Mithras sandstone is entirely different.

X.FR 782A Pilaster/base

Medium-grained sandstone (0.375 mm), with detrital muscovite flakes, black carbonaceous needles, and ochrous spots of limonite colour. This column portion is of identical lithology to Q.L. 1977.14 and .15, with matching grain size and inclusion suite.

X.FR 782 B+C Pilaster shaft portion

Two fragments, now glued together, square in section with lengthwise vertical grooves on some sides. Medium-grained sandstone (0.250–0.375 mm), comprised of well-sorted, sub-rounded quartz grains with detrital muscovite and carbonaceous black specks. There is a clay matrix that is sometimes stained by iron, which again is in evenly spaced specks and is an ochre colour, suggesting limonite. The lithology is remarkably homogeneous. The artefact shows brittle curving fracture, suggesting a well-cemented robust material. Similar lithology and grain size suggest that this is of the same sandstone as the column portions Q.L.1977.14 and .15.

X.FR 782D Pilaster capital

Medium-grained sandstone (0.250–0.375 mm), very well sorted, with sub-rounded grain shapes. Contains black carbonaceous flecks, detrital muscovite, lithic clasts and bleached white kaolinite pseudomorphing feldspar. Iron is present in evenly spaced specks of limonite which is ochre in colour. Iron banding is also present as secondary leisegang rings. One side of the object is notably paler, suggesting it has been plastered or painted. Similar lithology and grain size suggest that this is of the same sandstone as the column portions Q.L.1977.14 and .15.

X.FR 782E Pilaster shaft portion

This fragment has no recent breaks, making examination difficult. Three faces of the square column are bleached white or painted/plastered. It is again comprised of a medium-grained sandstone (0.250–0.375 mm), with sub-rounded quartz grains, detrital muscovite, black flecks of carbonaceous material and a speckled distribution of iron oxide of limonite colour. There are patches of white matrix clay. This appears to be of the same lithology as Q.L.1977.14, Q.L.1977.15.

X.FR 783 Shaft fragment

This object has surface ornamentation (carving) that differs from the others so far examined, but otherwise the lithology is similar. It is comprised of a medium-grained sugary sandstone (0.250–0.375 mm), with sub-rounded quartz grains and detrital muscovite flakes. There are no recent breaks to aid examination, but one patch reveals a speckled distribution of ochrous iron as well as a needle-like carbonaceous inclusion. This appears to be of the same lithology as Q.L.1977.14, Q.L.1977.15.

These eight artefacts, Q.L.1977.14, Q.L.1977.15, X.FR 782 A-E and X.FR 783, are all made of sandstone of closely matching lithology.

3119/5\ Armchair voussoir - Howe Mire

Grain size is 0.250–0.375 mm with an average of 0.375 mm. This is finer grained than other sandstones from the assemblage of artefacts from Howe Mire. Where glimpses through mud cover allow inspection, the sandstone is comprised of quartz grains in a white matrix of clay, giving a vivid white sandstone similar in that respect to other objects examined from this site. Detrital muscovite is present.

3119/6\ Rectangular block - Howe Mire

Mud cover hampered an extensive investigation of this object. Small mud-free areas revealed a grain-size variation of 0.375–0.500 mm with sub-rounded quartz grains in a white clay matrix. Areas that lack this clay matrix show a sugary texture of glassy quartz in grain contact (i.e. clast-supported). Detrital muscovite flakes were noted. There is no evidence of iron staining in this sandstone.

3119/7\ Armchair voussoir - Howe Mire

This sample has a large damaged area, free of mud cover, allowing more thorough examination. Grain size is 0.250–0.375 mm and is well sorted. Quartz grains sit in a vivid white clay matrix and iron staining is not present. Clear flakes of detrital muscovite are abundant. A vitreous pink grain was noted and is presumed to be a detrital fragment of garnet. This lithology has similarities to other artefacts from Howe Mire examined and differs only in being finer grained.

3119/8\ Rectangular block - Howe Mire

Coarse sandstone (0.375–1.500 mm) with sub-rounded quartz grains. Muscovite is present as translucent single flakes. Mud cover makes further inspection difficult but one area shows ingress of iron oxide (of limonite colour), showing that this sandstone is easily iron-stained, but that this is a very localised phenomenon.

3119/9\ Armchair voussoir (incomplete) - Howe Mire

This object has mud cover. Grain size is 0.375–0.750 mm; grains are sub-rounded. The matrix is a bleached white, suggesting kaolinite which sometimes forms blocks, probably from *in-situ* feldspar decomposition. Clear muscovite flakes were noted. There are areas of open porosity, especially where grain size is coarser, giving a sugary texture. Vitreous pink grains are present and are presumed to be detrital garnet grains.

3119/10\ Armchair voussoir- Howe Mire

Large worked slab in distinctive shape with broken surface at front offering good inspection. Comprised of very poorly sorted sandstone with grain size varying from 0.375–5 mm with most grains in the 0.500–2 mm size range (see ONLINE FIG. 51). Greyish vitreous quartz in a white clay matrix makes the sandstone relatively colourless (Munsell 7.5YR 8/1), lacking iron staining. There is some detrital muscovite present but it is scarce compared to others inspected and the muscovite here is distinctly clear rather than golden. Feldspar is present as polished detrital grains and is euhedral in shapes of 2 mm size. Pink vitreous irregularly-shaped angular grains are presumed to be garnet. This sandstone is similar to that of the Mithras altar, sharing the same grain-size range, with the lack of iron staining giving it a bleached white appearance (ONLINE FIG. 52). The materials differ, however, in their robustness, this slab being comprised of well-cemented grains, giving a strong material compared to the brittle and poorly-cemented Mithras lithology.

3119/12\ Plinth - Howe Mire

This large object was hard to examine due to mud cover, and too heavy to lift, so its description is short. Grain size exposed in scratches is 0.375–0.500 mm, with sub-rounded quartz grains in a white matrix presumed to be kaolinite. Muscovite flakes are present. There is evidence of iron staining introducing a limonitic ochre colour into the white matrix in places. The material is homogeneous, robust and strong. Munsell colour is 10YR 8/6, yellow.

3119/27\ Chamfered stone -Howe Mire

An odd-shaped artefact, with three clearly dressed sides. Recent damage provides surfaces for inspection of the lithology. Medium-grained sandstone (0.375 mm) of well-sorted, sub-rounded quartz grains and detrital muscovite in a matrix of white clay that is iron-stained in discrete patches. Munsell colour is 7.5YR 5/8 (strong brown), but there are also more rust-red patches. This lithology has a more open porosity and the matrix percent is here higher than in others examined. The slight lithological differences are seen as variations on a theme and could easily be explained as subtle differences within a formation or even within a bed at outcrop.

3119/28\ Armchair voussoir fragment -Howe Mire

Inspection of this object is hampered by mud cover and limited to areas where scratches reveal the underlying lithology. It is comprised of medium-grained sandstone (0.375 mm) of well-sorted, sub-rounded quartz grains with glinting muscovite flakes of similar size, in a white matrix. Ochre-coloured patches stain the matrix and are evenly spaced, the patches being 1–2mm in width. The Munsell colour is 7.5YR 5/8 (strong brown), giving the artefact a darker colour. This sandstone shares properties with other artefacts from Inveresk (column fragments Q.L.1977.14, Q.L.1977.15, X.FR 782 A-E and FR 783), although this specimen in more iron-rich.

3119/33\ Rectangular block - Howe Mire

A rectangular block with a chip on the lower left corner offering an inspection window. Sandstone of coarse grain size 0.500–2.0 mm and moderately sorted. Quartz grains are sub-rounded and they are at times suspended in a white clay matrix, suggesting matrix-supported texture and giving the sandstone a distinctive bleached white appearance. An ochre-coloured discrete clast was noted. This lithology is better sorted than the armchair voussoirs examined and entirely lacks the large clasts, although this difference could easily exist within an outcrop of sandstone within one bed. This material is very homogeneous and there is no evidence of bedding.

X.2005.5 Armchair voussoir - Howe Mire

Grain size is 0.375–0.750 mm. Quartz grains are sub-rounded and sit in a white clay matrix. Where clay is absent the quartz grains are glassy and show a sugary texture with a grain-supported fabric. Detrital muscovite flakes are clear and are abundant in this example.

Table 2. Petrographic summary (numbers are either NMS catalogue numbers or excavators' reference numbers)

no.	description	findspot	average grain size /mm	grain size range/mm	other detrital grains	matrix	colour	secondary effects
[004]	Mithras altar	Lewisvale Park	0.750	0.500–2.000	muscovite, kaolinitised feldspar, garnet	white clay	bleached white	discrete iron nodules
[007]	altar base	Lewisvale Park	1.000	1.000–2.000	muscovite, some biotite, kaolinitised feldspar, lithic clasts	white clay	bleached white	iron staining
[003]	Sol altar	Lewisvale Park	0.187	0.187–0.250	muscovite, kaolinitised feldspar, specks of iron oxide	white clay	10R 8/2-8/3 pink	leisegang rings of limonite
sf.17	building stone	Lewisvale Park	fine	well sorted		red clay	brick red	
Q.L.1977.13	Procurator altar	churchyard	0.375	0.375–2.000	muscovite, kaolinitised feldspar, garnet, chlorite, cubic metallic mineral	white clay	yellowish	
X.FV 31	pine cone	Midfield Mains	0.375	0.375–0.500	muscovite abundant, hematite (primary)	red hematite	10R 5/6 red	
X.FV 67	tombstone	Carberry	0.500	0.375–2.000	muscovite abundant, feldspar, large clay clast and carbonaceous inclusion	limonite stained clay	soil covered	
Q.L.1977.14	column portion	churchyard	0.375	0.250–0.375 (well sorted)	muscovite, kaolinitised feldspar, specks of iron oxide, carbonaceous inclusion, rip up clast		ochre - speckled	leisegang rings of limonite
Q.L.1977.15	column portion	churchyard	0.375	well sorted	muscovite, specks of iron oxide,carbonaceous clast and grains	white clay	peach - speckled	
X.FR 782A	pilaster/base	churchyard	0.375		muscovite, carbonaceous needles, spaced specks of limonite	white clay	ochre - speckled	
X.FR 782B+C	pilaster shaft portion	churchyard	0.375	0.250–0.375	muscovite, carbonaceous needles, spaced specks of limonite	white clay	ochre - speckled	

no.	description	findspot	average grain size /mm	grain size range/mm	other detrital grains	matrix	colour	secondary effects
X.FR 782D	pilaster capital	churchyard	0.375	0.250–0.375	muscovite, carbonaceous needles, kaolinitised feldspar, lithic clasts, spaced specks of limonite	white clay	ochre - speckled	leisegang rings of limonite
X.FR 782E	pilaster shaft portion	churchyard	0.375	0.250–0.375	muscovite, carbonaceous needles, spaced specks of limonite	white clay	ochre (with plaster)	
X.FR 783	shaft fragment	churchyard	0.375	0.250–0.375	muscovite, carbonaceous needles, spaced specks of limonite		ochre - speckled	
3119/5\	armchair voussoir	Howe Mire	0.375	0.250–0.375	muscovite	white clay	bleached white	
3119/6\	rectangular block	Howe Mire		0.375–0.500	muscovite	white clay	soil covered	
3119/7\	armchair voussoir	Howe Mire	0.375	0.250–0.375	muscovite, garnet	white clay	bleached white	
3119/8\	rectangular block	Howe Mire	1.000	0.375–1.500	muscovite (clear)	white clay	soil covered	leisegang rings of limonite
3119/9\	armchair voussoir	Howe Mire	0.500	0.375–0.750	muscovite (clear), kaolinitised feldspar, garnet	white clay	bleached white	
3119/10\	armchair voussoir	Howe Mire	0.500–2.000	0.375–5.000	muscovite (clear), kaolinitised feldspar and garnet	white clay	bleached white 7.5YR 8/1	
3119/12\	plinth	Howe Mire	0.375	0.375–0.500	muscovite	white clay	10YR 8/6 yellow	limonite staining at base
3119/27\	chamfered stone	Howe Mire	0.375		muscovite	white clay	7.5YR 5/8 strong brown	spaced iron staining
3119/28\	armchair voussoir	Howe Mire	0.375		muscovite	white clay	7.5YR 5/8 strong brown	spaced iron staining
3119/33\	rectangular block	Howe Mire	0.750	0.500–2.000	muscovite, iron rich clast or nodule	white clay	bleached white	
X.2005.5	armchair voussoir	Howe Mire	0.500	0.375-0.750	muscovite abundant	white clay	bleached white	

The Mithras altar (ONLINE FIG. 53)

This sandstone is poorly sorted with a large grain size range, with quartz grains up to 5 mm within the thin-section. Many quartz grains are elongate, being four times longer than wide, giving them a rectangular shape which suggests little transport. These are aligned forming a planar fabric that defines the bedding orientation. Bedding is also suggested by the systematic grain-size variation interpreted as graded bedding. There are many irregular grain shapes and most are angular to subangular, again suggesting little abrasion during transport which must therefore have been short in duration. Many irregularly shaped quartz grains look like those seen as a late-stage crystallisation mineral in igneous rocks such as granites and are thought to reflect an original source from the weathering and erosion of such terrigenous rock types. Some quartz grains show inclusion trails, giving them a dusty appearance.

The porosity is estimated to be at least 20 per cent by area, with some patches looking as if the grains are barely in contact with each other. Muscovite is present, but is rare in the slide. Where present it is in particular layers, again suggesting parallel bedding deposition. Feldspar is common and is often perthitic (an exsolution texture seen in alkali feldspars of igneous origin). Some feldspar is still articulated with other minerals such as quartz, suggesting a lithic inclusion of granite. One large quartz grain has an inclusion of feldspar, again suggesting an igneous source such as granite for these detrital grains. There are also composite quartz grains showing sutured texture suggestive of quartzite, a metamorphic rock. This suggests the sediment source was a continental area where granite and metamorphic rocks such as quartzite were exposed and weathered, this detritus being transported over a relatively short distance before deposition as the sandstone that we now see. Some feldspar crystals show *in-situ* damage such as slippage on cleavage planes or fracturing. It is hard to tell if this occurred during compaction or during thin-sectioning but it does show one of the causes of weakness in the sandstone and hence the altar itself.

A very significant minor detrital component is garnet. This is noted by its high relief in plane-polarised light and its isotropic nature in cross-polarised light which is diagnostic. These grains have irregular shape being elongate but very irregular in outline. One was noted with arcuate cracks and some alteration along this crack. These crushed fragments of garnet can only be terrigenous in origin. A small, high relief grain with high birefringence could be zircon or monazite. There are also greenish brown wispy fragments of a mineral that is perhaps chlorite. A small amount of an opaque mineral is present in a clearly secondary context and is presumed to be iron oxide.

Staining discriminates the difference between empty pore space and that filled with clay minerals that absorb some blue stain and are paler blue. At higher magnification these paler areas are seen to be granular and somewhat turbid. Some show many small elongate crystals displaying high interference colours and cleavage and are in random cross-cutting relationships with each other. This is again presumed to be sericite, which forms from the *in-situ* break down of feldspar grains

Altar base (ONLINE FIG. 54)

This sandstone is moderately well sorted with an average grain size of 0.250–0.375 mm and some grains up to 1 mm. This is finer grained than the general description by hand lens of the whole altar base and suggests a fine-grained sample of the stone has been sectioned. It displays a mixture of grain shapes with some rectangular grains with sharp corners, but also some high sphericity, well-rounded grains. Most grains are angular to subangular. Opaque secondary minerals stain the intergranular areas with a regular spacing of 1–2 mm. This is presumed to be iron oxide, noted in the macroscopic examination of this stone.

The sandstone contains muscovite as well as biotite which is altering to chlorite, similar to that seen in the Mithras thin section. Feldspar grains are present and show cross-hatched twinning in cross-polarised light which suggests microcline. Many grains show cleavage and breakage *in situ*. The staining of the slide shows some areas of paler blue which are presumed to be stained clays which form the matrix of the sedimentary rock. These contrast with the empty spaces which suggest an open porosity of 15–20 per cent by area. A lithic fragment of quartzite is seen with sutured quartz grains. Some quartz grains show inclusion trails, giving them a dusty appearance.

The Sol altar (ONLINE FIG. 55)

This sedimentary rock is well sorted, showing little grain size variation. It is fine grained with grains averaging 0.187 mm in diameter; a large proportion are smaller than this. Grain shapes are sub-rounded overall and have low sphericity, most grains being somewhat rectangular (twice as long as wide). The rock is very porous with the staining revealing a porosity of *c.* 10–15 per cent by area. Areas of secondary opaque mineral formation are noted, forming irregular intergrain areas at fairly regular spacing. This is presumed to be the hematite speckling noted when examining the altar itself. (Opaque minerals cannot be specifically identified with the petrographic microscope.) Muscovite is abundant in the slide, forming elongate thin shapes which are slices through the flakes noted in the inspection of the altar itself. These micas are aligned parallel to each other where present and define the bedding surface in the sandstone as they landed flat on the bedding plane when deposited. Post-depositional compaction has caused some micas between quartz grains to be bent.

The clay matrix is evident in the thin section where it has absorbed some stain and is pale blue. The specific clay cannot be identified by this optical method. Examination at higher magnification (400X) and cross-polarised light shows some of these areas to be more complex, comprised of abundant needle-like laths with bright interference colours and intersecting at 60- and 120-degree angles. This is presumed to be the *in-situ* break down of feldspar to sericite and suggests therefore the deposition of feldspar in the original sediment, implying mineralogical immaturity. This is confirmed by other observations of unaltered feldspars in the thin section, showing diagnostic lamellar twinning in cross-polarised light. A lithic clast of quartzite with sutured quartz grains was seen.

Thin sections – conclusions

Comparison of the sandstones examined by thin section shows that the Mithras sandstone is coarser grained, has greater pore space, has much more detrital feldspar and has less mica. The Mithras sandstone also has detrital garnet grains which are unusual and are therefore a diagnostic feature of this sandstone. The three sandstone types differ in terms of grain size and sorting but share features in common such as the presence of feldspar and muscovite as well as a clay matrix. All three sandstones look to be the result of weathering of continental rocks with the transport of grains over varying distances. The Sol sandstone and the altar base both show evidence of longer transport before deposition, resulting in better sorting, smaller average grain size and clearer bedding. The Mithras sandstone is notably poorly sorted and coarse grained and includes the highest feldspar percentage, suggesting short transport of grains liberated by erosion before deposition. The coarse grain size suggests fairly high-energy conditions, possibly those that result from river transport during high flow rate events. The range of features seen in the three sandstones are characteristic of the depositional environments suggested for Carboniferous age sandstones which outcrop in the area today. These are discussed in a later section of this report.

XRD Analysis *By* British Geological Survey Microanalytical Facility

Quantitative X-ray diffraction analysis of a fragment of the Mithras altar was carried out by the British Geological Survey Microanalytical Facility.[5] The results show that the sample contained 75.8±2.5 per cent quartz, 13.6±10 per cent kaolin, 7.8±20 per cent potassium feldspar, 2.7±40 per cent mica and less than 0.5 per cent calcite (errors are relative). Mica and kaolin are generic terms here and could represent a list of specific potential minerals in these groups. The quartz and feldspar percentage allow the lithology to be named officially as subarkose. The XRD data confirm the visual and thin section examination, showing that the Mithras sandstone is indeed an immature sandstone with a very large feldspar component and a high clay percentage from its breakdown. The matrix is not calcite, as is typical of some Carboniferous Period sandstones of the area (specifically of the Calciferous Sandstone Measures), but is kaolinite, a group term covering several soft clay minerals. This also explains the poor strength of the material and its propensity to fragment as it is bonded by a weak clay. The lack of any iron mineral in the analysis explains the pale colour of the sandstone. It is possible that both iron minerals and calcite were leached from the sandstone during diagenesis. It should also be considered that burial for over 1,500 years in soil is likely to have modified the composition of the rock in terms of the loss of soluble components especially by humic acid in the soil.

[5] Wagner 2012.

DISCUSSION (see further in main text)

The two Inveresk altars are of different sandstone types. The Mithras altar and the altar base are a similar coarse-grained white sandstone with a similar inventory of other detrital grains (muscovite, biotite and kaolinitised feldspar). The differences between the Mithras altar stone and the altar base are not considered significant and are typical of the heterogeneities seen across outcrops of such sandstones. Although the altar base was of a very homogeneous block of such material, the Mithras altar, being larger, showed evidence of bedding with grain-size variation between beds and horizons of particularly coarse angular grains of quartz. The overall character of the Mithras (and altar base) sandstone is typical of fluvial sandstones. Grain-size fluctuations are easily explained in terms of current velocity variations at the time of deposition. The Procurator’s stone was remarkably similar to the Mithras and altar base lithologies, and especially to the Mithras lithology in terms of quartz grain-size range and, significantly, the presence of detrital garnet grains. The Carberry tombstone, although similar in grain size to the Mithras altar and the Procurator’s stone, is ferruginous and has large clay rip-up clasts as well as carbonaceous inclusions that suggest a different source of more typical Carboniferous sandstone.

The Sol altar by contrast is fashioned from a pink, well-sorted sandstone of much finer grain size. It has similar minor components (mica and kaolinitised feldspar) to the Mithras sandstone and also has a clay matrix. The colour of the Sol sandstone results from iron staining of the clay matrix and is variable in its distribution. Iron minerals form a spaced distribution of speckles, are sometimes concentrated on particular horizons thought to represent bedding planes and can also form secondary leisegang rings where iron has washed into the sandstone more recently. The Sol sandstone is remarkably homogeneous and the slab showed little variation. Its homogeneity, finer grain size and better-cemented nature make it the far better choice of material for stone carving. The difference in the sandstones of the two altars could be explained by variations in the depositional character of the original sediment followed by subtle differences in their post-depositional history. Both sandstone types share common features with local sandstones of the Carboniferous Period.

The other artefacts from the Inveresk area examined fell into a few categories. The column fragments Q.L.1977.14, Q.L.1977.15, X.FR 782 A-E and X.FR 783 were all of the same medium-grained sandstone characterised by its glinting muscovite flakes, black specks of carbonaceous material and even distribution of iron speckles that were an ochre colour suggesting limonite. This lithology also showed remarkable homogeneity in that it lacked clear bedding or sedimentary structures. The colour, grain size, presence of muscovite and carbonaceous specks are all features common to local Carboniferous age sandstones and support a local source, although sandstones with such properties are common in other parts of Britain and beyond. The similarity of this group of artefacts in type and lithology does suggest one source of material was exploited in their manufacture with a definite attempt to make them match. A thick bed of homogeneous sandstone that lacked bedding was obviously selected.

Of the 11 objects examined from Howe Mire, several have strong lithological similarities to the sandstone of the Mithras altar and the altar base from Inveresk. The armchair voussoirs from Howe Mire (particularly 3119/9\, 3119/10\) are similarly coarse grained with a white clay matrix and lack iron staining. They also have in common muscovite, kaolinitised feldspar clasts, as well as fragments of detrital garnet (appearing as pink, vitreous grains) which is quite distinctive. (A large rectangular block from Howe Mire (3119/33\) was similarly coarse grained with similar minor components, but lacked garnet.) Despite these lithological similarities, there are also major differences in the physical properties of the two sandstones, the Mithras lithology being poorly cemented and susceptible to brittle fracture while the Howe Mire armchair voussoir lithology is strong, robust and more homogeneous. These differences could represent differences within the same formation either due to depositional fluctuations or different diagenetic of recent burial histories, but equally they may reflect different sources. The presence of the detrital garnet in these objects does seem a significant linking factor however.

Other objects from Howe Mire (3119 /5,6,7,12,27\, X.2005.5) have some lithological similarities such as the white clay matrix and detrital muscovite but are much finer grained and sometimes exhibit secondary iron staining. The finer grain size would make other possible features (such as garnet grains) very hard to spot using a hand lens, and soil cover also hampered examination of some of these objects. As such, this finer-grained white clay-rich sandstone could easily be from the same source as the coarse-grained (garnet-bearing) white sandstone, reflecting the natural grain-size variation within a bed or a formation. One artefact from the Howe Mire assemblage, a fragment of armchair voussoir (3119/28\) is lithologically similar to the group of column shafts, bases and capitals from Inveresk.

Geological background information

Inveresk sits within the Midlothian Coalfield, a wide syncline of Carboniferous-age sedimentary rocks (ONLINE FIG. 56). This is part of a far larger area of Carboniferous and Devonian-age strata that are exposed across the width and length of the Midland Valley, stretching from the Highland Boundary Fault to the Southern Uplands Fault. This large area offers many potential sources of sandstone of various geological ages and led to the dominance of this lithology in building stone for centuries in the area. Carboniferous and Devonian-period sandstones were deposited in various depositional environments from arid terrestrial to deltaic to marine and at various palaeolatitudes from subequatorial desert to tropical equatorial. Consequently the sandstones vary widely in type and appearance. Generally, Devonian-age sandstones are characteristically red due to the presence of hematite (iron oxide), leading to the lithostratigraphic term Old Red Sandstone. They are also well sorted and fine grained. Carboniferous-age sandstones vary widely in grain size and colour, ranging from bleached white to iron-stained, either an ochre colour by the presence of hydrated iron oxide (limonite) or red (due to hematite).

During the Carboniferous Period (359–299Ma) the Midland Valley of Scotland was an area of low ground flanked to the north by the Highlands and to the south by the Southern Uplands massif, much as it is still today but with far greater topographic contrast. It formed a substantial, fault-bounded depositional basin contemporary with other examples in northern and central England and much further afield. Cyclic sea-level fluctuations led to repeated sequences of marine and terrestrial deposits. Each of the cycles produced a sequence from marine limestones followed by a coarsening upwards pile ranging from mudstones and siltstones up into planar and cross-stratified sandstones of undoubted terrestrial origin representing alluvial material.[6] On top of these sandstones are fossil soils (seatearths) and thin coal seams representing the remains of terrestrial vegetation accumulating in a swamp or marsh setting. The deltaic sandstones result from huge volumes of sediment being discharged in a coastal setting, accumulating in large fans. Provenance studies of these deltaic sediments suggest a northern source which supports a model of deltas prograding southwards, filling the marine rift basin.[7] Palaeogeographic maps[8] suggest this basin was part of a relatively narrow seaway which had considerable lateral (east–west) extent (more than 3,000 km) extending as far as Russia where similar deltaic sediments are found. In the Midland Valley the alluvial material was mainly derived from the Highlands to the north, where the Caledonian Mountains were being actively eroded after their relatively recent uplift, providing sediment dominated by the breakdown products of basement metamorphic rocks and granites. Such a source results in sandstones with lithic clasts and detrital grains of micas and feldspars as well as metamorphic minerals like garnet, but of course dominated by quartz.

The Midlothian Coalfield is a saucer-like downfold of strata (a syncline) that leads to the repetition of units to the east and west of its axis which runs roughly NNE–SSW and is centred near Musselburgh. Within this sequence is the Passage Formation which is characterised by thick sandstones (sometimes greater than 30 m thick) which are pebbly in places and are interlayered with coal seams and fossil soils. The Passage Formation is part of the Clackmannan Group which is Namurian in age, a subdivision of the Upper Carboniferous. This makes it equivalent to the Millstone Grit Series of England. The basal part of this sedimentary grouping is a massive sandstone unit, the Roslin Sandstone Formation.[9] Good access to this formation today is found in the intertidal exposures along the shore at Joppa where the steeply dipping strata allow a walk through the sequence. Other exposures of this particular sandstone are noted within the Bilston Burn, a tributary of the river North Esk.[10] In fact the map distribution of this sandstone formation sweeps from Joppa all the way through Roslin and beyond Penicuik in a band of varying width (ONLINE FIG. 56). To the other side of the synclinal axis another band of the same formation outcrops from east of Musselburgh, skirting the eastern edge of Inveresk and continuing all the way past Newbattle to Carrington Mill.[11] At Roslin there are high cliffs of near-horizontal coarse sandstone on each side of the river, lying immediately under coals. The Passage Formation also bends round to the South Esk river between Carrington and Arniston Mains where it consists of red and white sandstone and quartz conglomerate.[12] The stratigraphy is not complete everywhere as units pinch out. The beds of sandstone are noted to be very inconsistent throughout the district, mainly due to their original deposition by laterally shifting delta channels.

Of course not all of this mapped distribution offers exposure at the surface, but there must be countless exposures in river gorges and coastal cliffs in the area. It is hard to look at the modern landscape, refashioned near Inveresk by extensive opencast coal mining, with its motorway and housing

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[6] Hunter 2001.
[7] Coe 2005.
[8] *ibid.*
[9] Cleal and Thomas 1996.
[10] Cossey et al 2004.
[11] BGS 2003.
[12] Howell and Geikie 1861.

developments, in terms of how it might have offered exposures of sandstone for Roman stone masons nearly two millennia ago. Coal extraction has radically changed the landscape and even redirected river systems. As such, it is unlikely that a specific locality can be suggested as a Roman quarry site. However, if locally available sandstones are of similar character to the artefacts examined, a local source of stone seems possible if not likely.

The coastal exposures at Joppa were examined at low tide in order to investigate whether the Roslin Sandstone exposed there (NT 320 734) had similar petrographic properties to the Mithras altar and the other artefacts of coarse white sandstone (the altar base and the Howe Mire armchair voussoirs). The thick sandstone layer is easily located as it forms the most massive bed and juts furthest out into the Forth, being the most erosion resistant of the lithologies exposed. It is a thick homogeneous white sandstone that is overlain by a grey mudstone with carbonaceous material (see ONLINE FIGS 57–58). From this mudstone layer, vertical carbonaceous tendrils drill downwards into the underlying sandstone, representing fossilised plant rootlets from Carboniferous-age plants. The sandstone is very white, typical of ganisters underneath coal seams where plants have leached soluble components from the porous substrate. The grain size varies and there are coarse horizons with angular milky quartz grains (see ONLINE FIG. 58), some of which might be quartzite lithic fragments. These layers of coarse grains define bedding. There are sharp changes in grain size from layer to layer. Other parts of the exposure show a secondary introduction of iron oxide in concentric rings (leisegang rings) (see ONLINE FIG. 59).

Samples of the sandstone from these exposures were examined with a binocular microscope and filtered light at a range of magnifications. Grain size varied from 0.375 mm to 0.500 mm but with angular grains up to 1.500 mm. The sandstone was found to be poorly cemented with a bleached white, soft clay matrix. Chalky white blocks of kaolinite were noted and interpreted as *in-situ* weathering of detrital feldspar grains. Some pinkish vitreous grains were noted but appeared to be stained quartz. Other samples from the site contained undoubted detrital garnet grains. Three samples were examined and showed varying grain size, some better sorted than others and with variable friability due to varying properties of the cement that held the grains together. Muscovite was seen in some samples but was not particularly abundant.

Coastal sandstone exposures at Skateraw, near Dunbar were also examined. These sandstones are older than those at Joppa, being Dinantian in age (equivalent to the Carboniferous Limestone Series). These sandstones are notably bleached white with abundant muscovite in particular horizons. Microscope examination of samples from Skateraw reveal vitreous sand grains (0.250–0.375 mm) in a white clay matrix. Some samples were very muscovite-rich and one was so clay-rich as to be matrix-supported (sand grains suspended in clay matrix). All the samples examined from Skateraw had detrital garnet grains as well as chlorite.

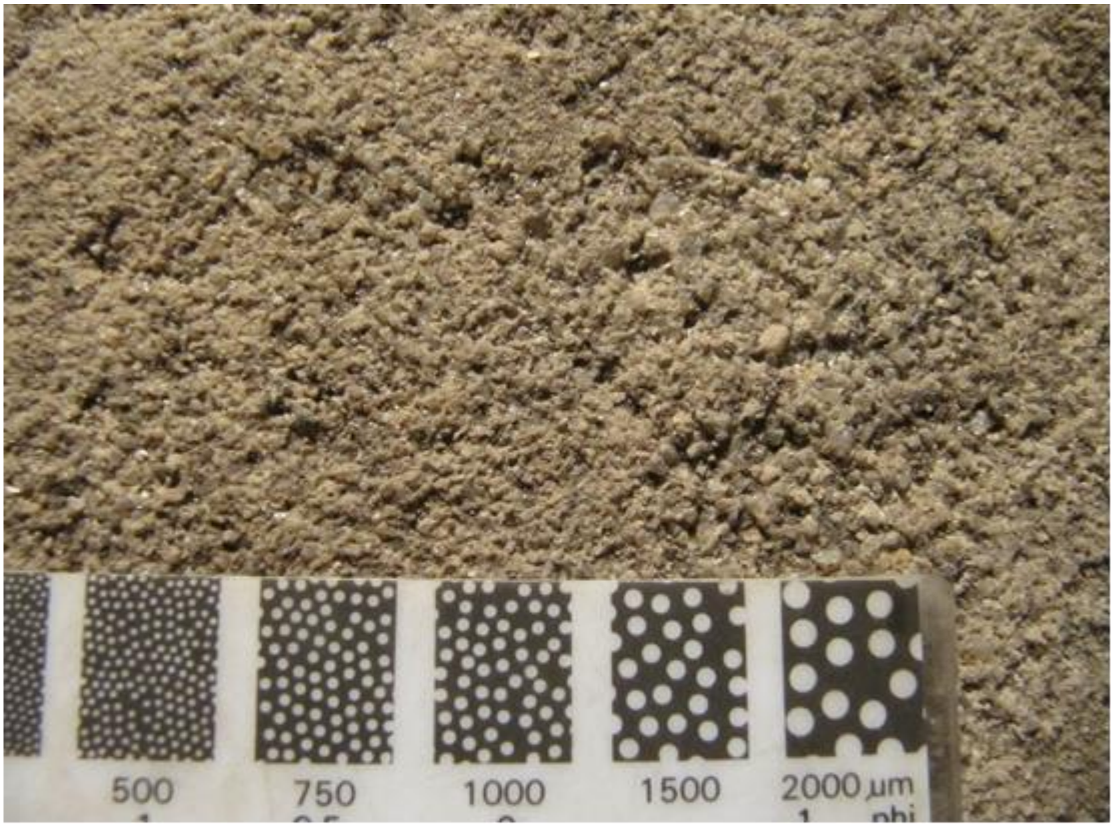
CONCLUSIONS

The Mithras altar and the altar base from Inveresk, as well as the voussoir slabs from Howe Mire, are made of a distinctive white coarse sandstone which contains abundant white clay (sometimes in feldspar-shaped blocks) as well as muscovite and unusual detrital grains of garnet. The Procurator Stone is also grouped with these objects due to convincing lithological similarity. Bleached, kaolinite-rich sandstones (ganisters) are often geologically associated with coal-bearing strata where they occur directly beneath seatearths (palaeosols). Sandstones of similar appearance were found with little effort in coastal exposures at Joppa not far from Inveresk. It is not suggested that these were the actual sources of the sandstone for the Mithras altar and lithologically similar artefacts, but it is significant that similar sandstones are locally available. The geology of the area offers an extensive outcrop area of this particular sandstone in a horseshoe-shaped belt that sweeps inland for *c.* 20 km before looping back round and ending up at the coast near the Musselburgh ash lagoons. Actual exposures will be dictated by faults and by the landscape of the area, with river gorges being the best examples of inland exposure today. There are abundant exposures of sandstone of other ages in the wider area, some of which also share petrographic characteristics with the distinct Mithras lithology, such as at Skateraw, near Dunbar. Carboniferous sandstones however are not limited to the Midland Valley, this local trough being only a small part of a laterally extensive series of depositional basins that stretch as far east as Russia and south into northern and central England.

Eight sandstone architectural objects, pilaster shafts, capitals and bases, excavated at Inveresk and now in the collection at the National Museum of Scotland, were found to be of matching medium-grained ferruginous sandstone, sharing many detailed petrographic features in common. These objects, although differing in colour, are similar in grain size and sorting to the Sol altar. These sandstones differ markedly from that used to fashion the Mithras altar and the other objects of similar coarse white sandstone listed above. Such finer-grained ferruginous sandstones are typical of many local Carboniferous-age strata and there are any number of potential local sources. The Carberry tombstone is of much coarser grain size than the pilasters but is similarly ferruginous and includes carbonaceous material which is typical of Carboniferous sandstones.

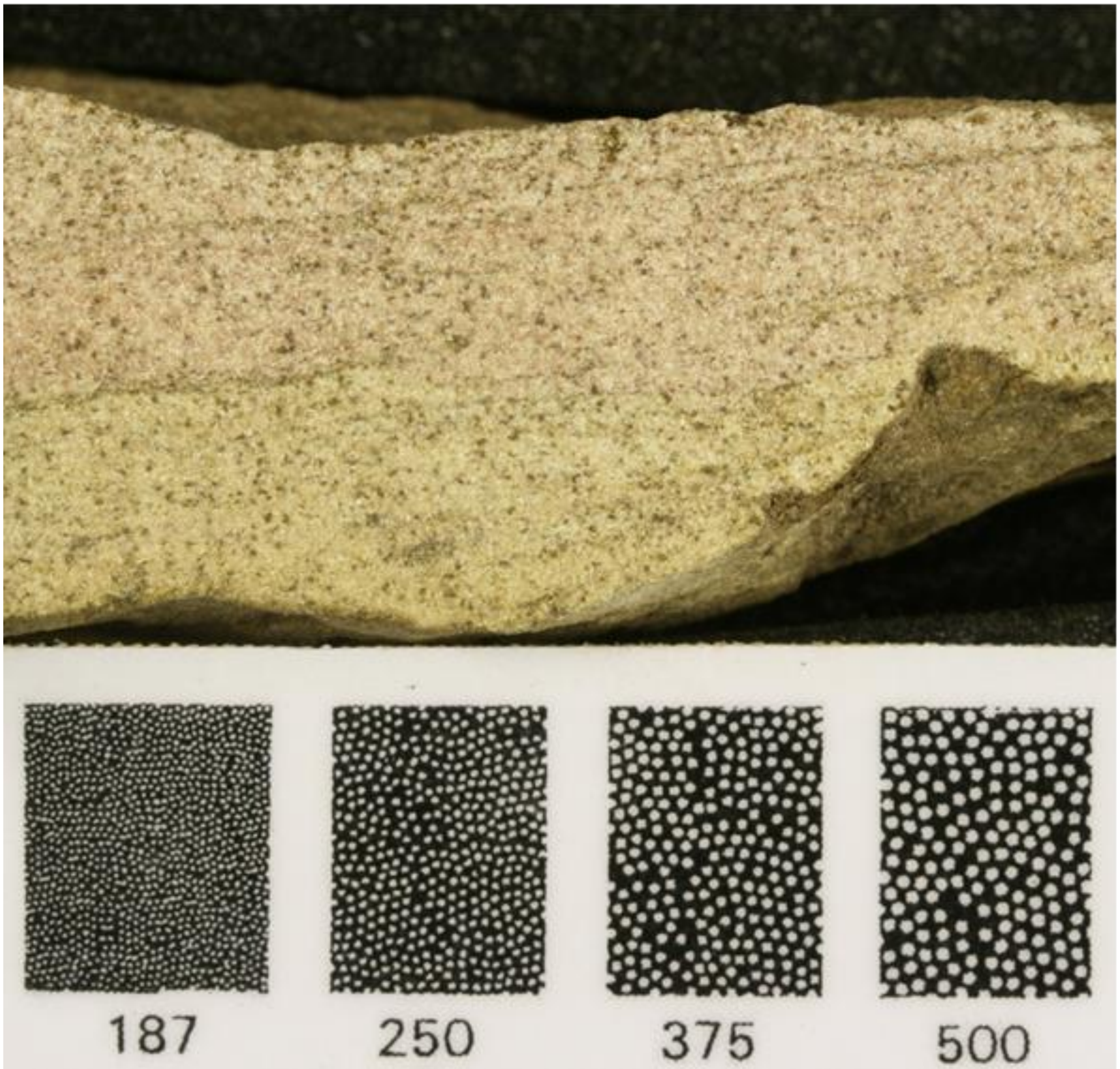
The pinecone sculptured stone (X.FV 31) is the odd one out in the assemblage of Roman objects examined, being made of very well-sorted, homogeneous red sandstone suggestive of an arid depositional environment rather than a fluvial source. In the context of the Midland Valley this would suggest a Devonian-age sandstone of which there would be countless potential local sources. Desert red sandstones of Permian age however are also a possible match and if it were of such material it would have been sourced from further afield. The nearest outcrops of Permian desert sandstone can be found in northern England, Dumfries and Galloway, Ayrshire or Arran.

Sandstone artefacts are hard to provenance due to the ubiquity of the rock type and the heterogeneity of the lithology at outcrop. Within the Midland Valley of Scotland, sandstones of different geological periods, resulting from markedly different depositional environments, can be broadly distinguished. The Inveresk altars and the base compare favourably with two types of Carboniferous sandstone, one of distinctive appearance and origin. The three items are therefore similar to locally available sandstone, although it should be noted that sandstones of these types are by no means limited to the Midland Valley. Local sandstones could have been utilised to fashion these artefacts.

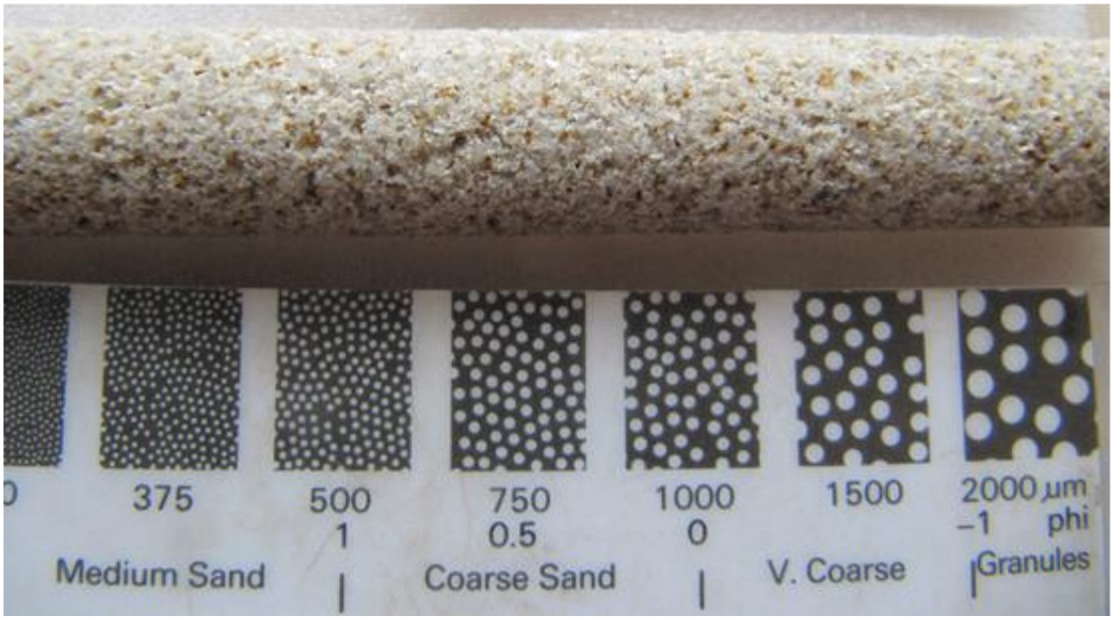


ONLINE FIG. 46. Mithras altar lithology with grain size chart for scale. (*Photo: F. McGibbon*)

ONLINE FIG. 47. Ferruginous nodules on front of Mithras altar. (*Photo: F. McGibbon*)

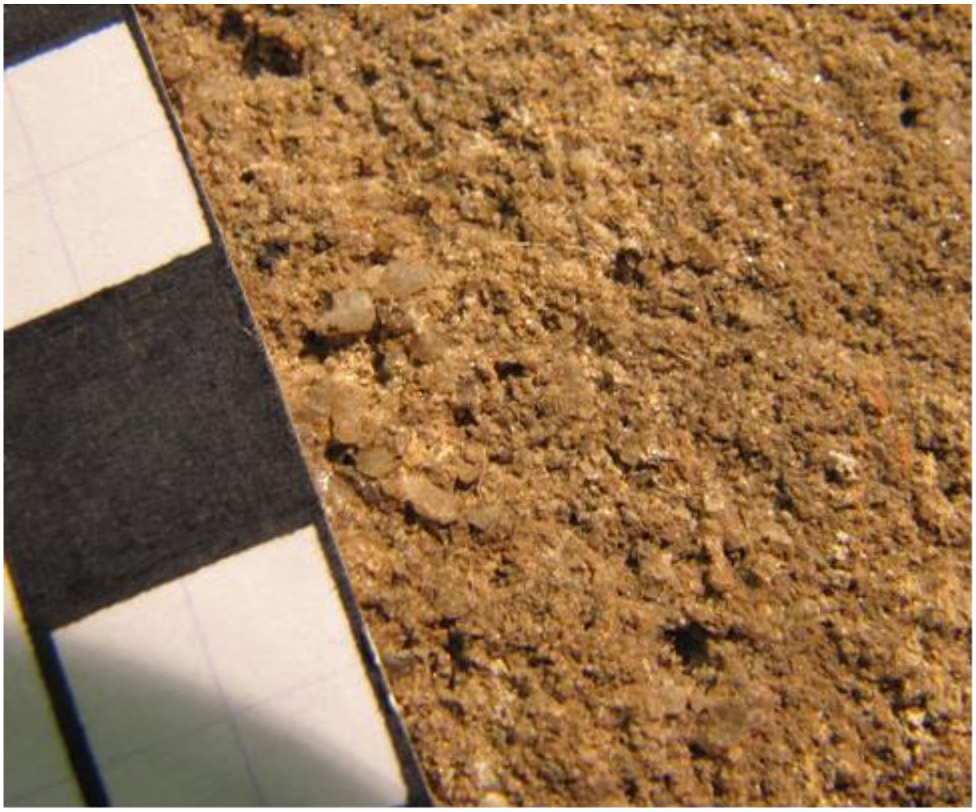


ONLINE FIG. 48. Sol altar fragment cut for thin-sectioning, showing lithological structure; scale in microns. (*Photo: F. McGibbon*)



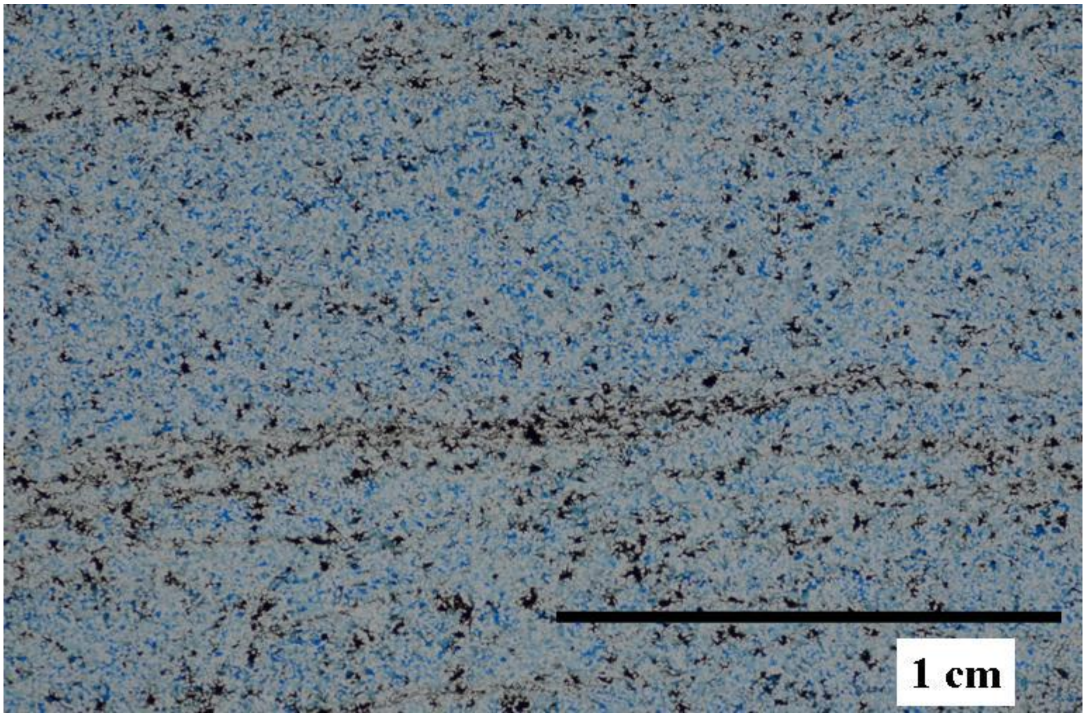
ONLINE FIG. 49. Core from base of Procurator Stone produced when prepared for mounting for exhibition. (*Photo: F. McGibbon*)

ONLINE FIG. 50. Pinecone sculpture, X.FV 31. (*Photo: National Museums Scotland*)

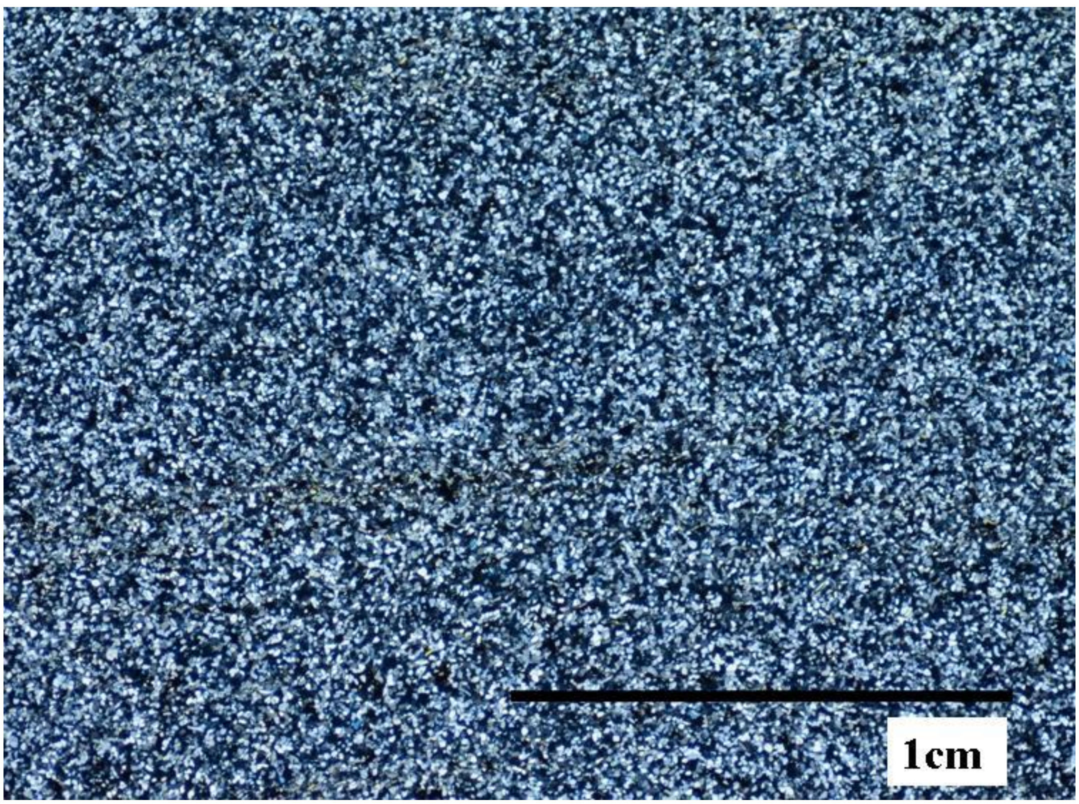


ONLINE FIG. 51. Howe Mire armchair voussoir (3119/10\) detail. (*Photo: F. McGibbon*)

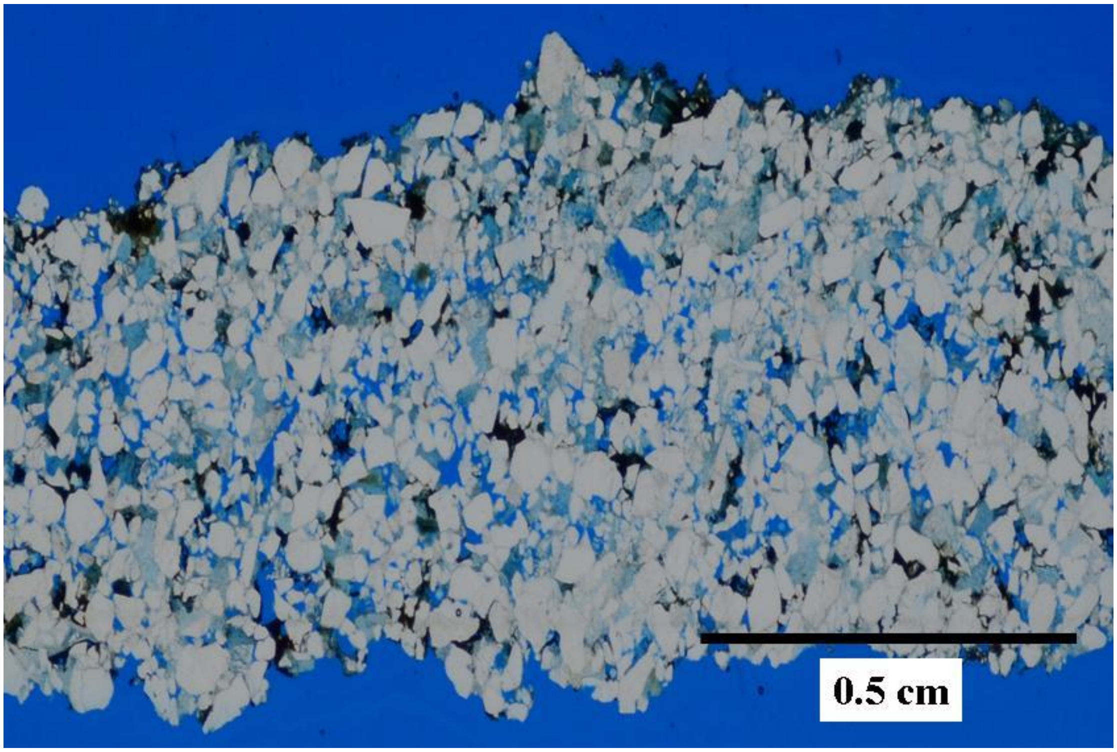
ONLINE FIG. 52. Howe Mire armchair voussoir (3119/10\) with fragment from Mithras altar for comparison. (*Photo: F. McGibbon*)



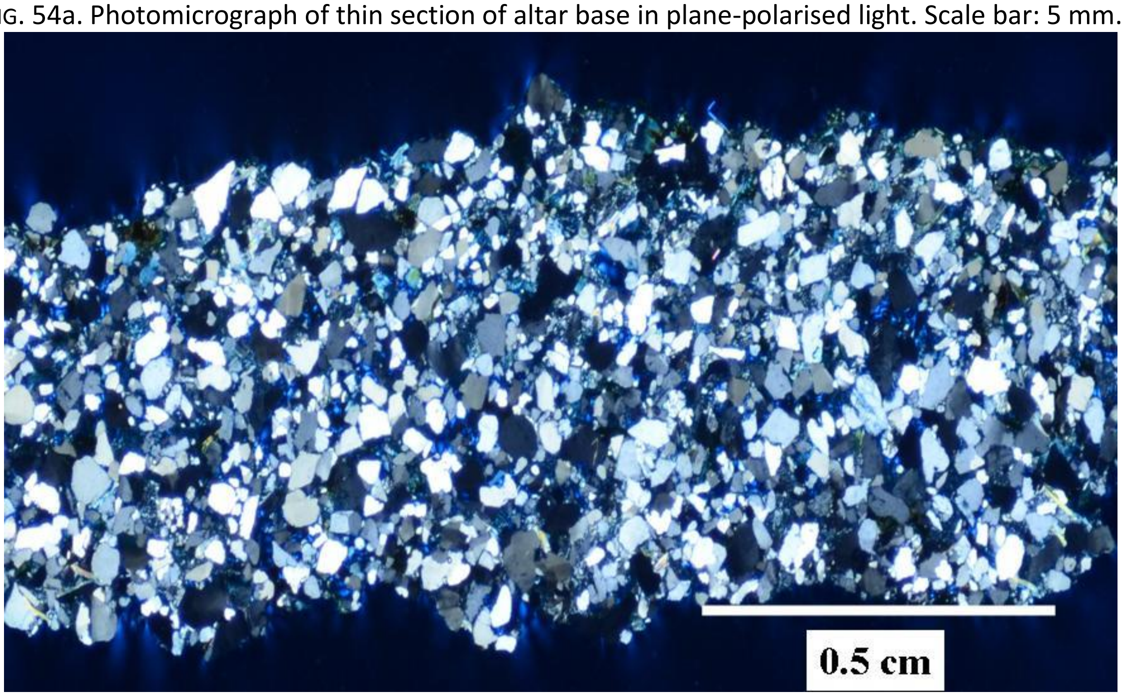
ONLINE FIG. 53a. Photomicrograph of thin section of Mithras altar in plane-polarised light. Scale bar: 10 mm.



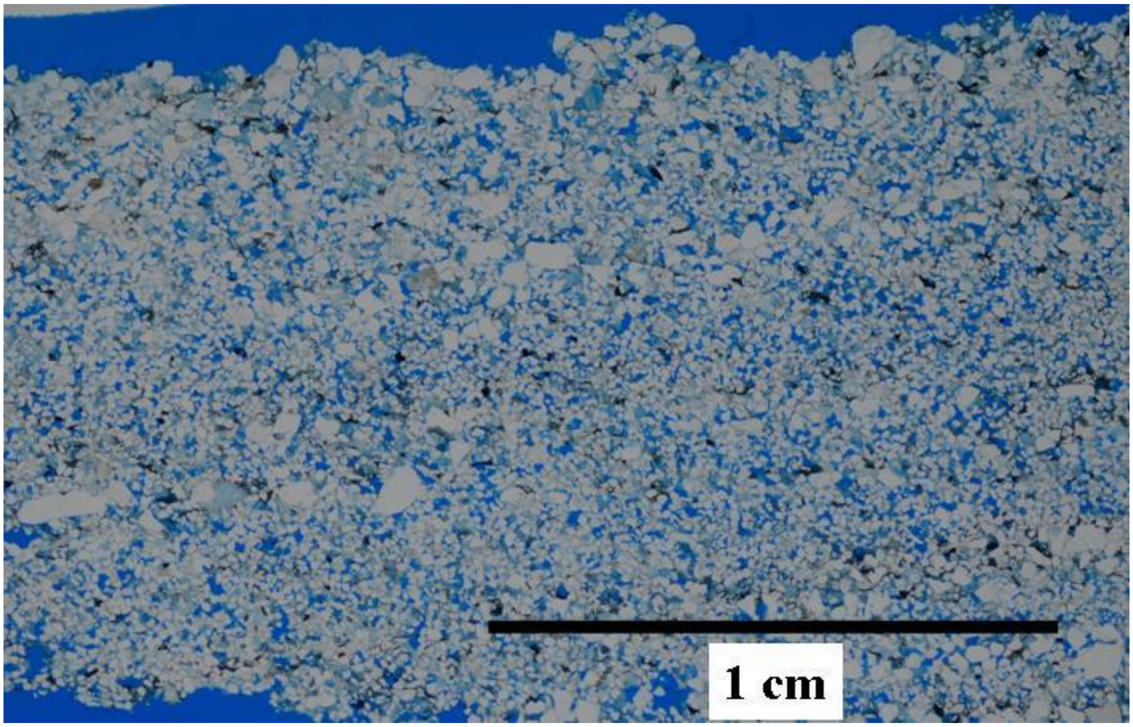
ONLINE FIG. 53b. Photomicrograph of thin section of Mithras altar in cross-polarised light. Scale bar: 10 mm. (*Photos: F. McGibbon*)



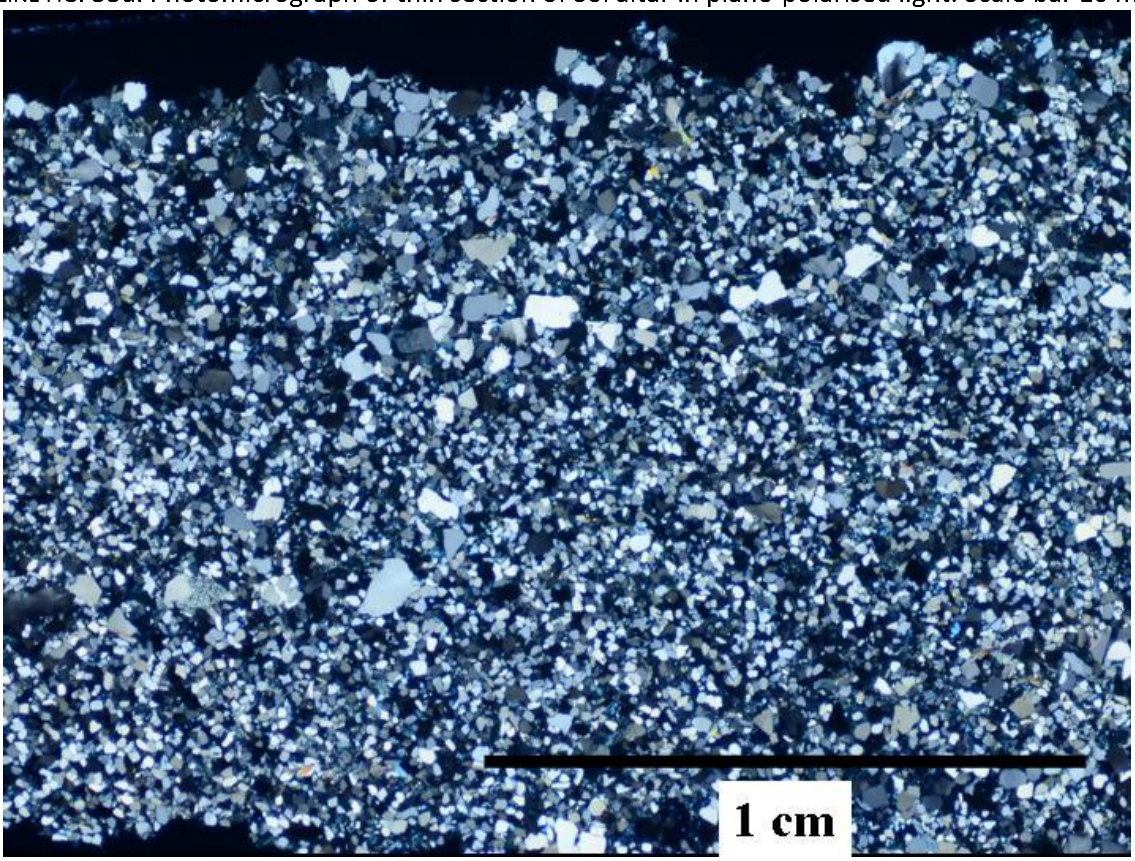
ONLINE FIG. 54a. Photomicrograph of thin section of altar base in plane-polarised light. Scale bar: 5 mm.



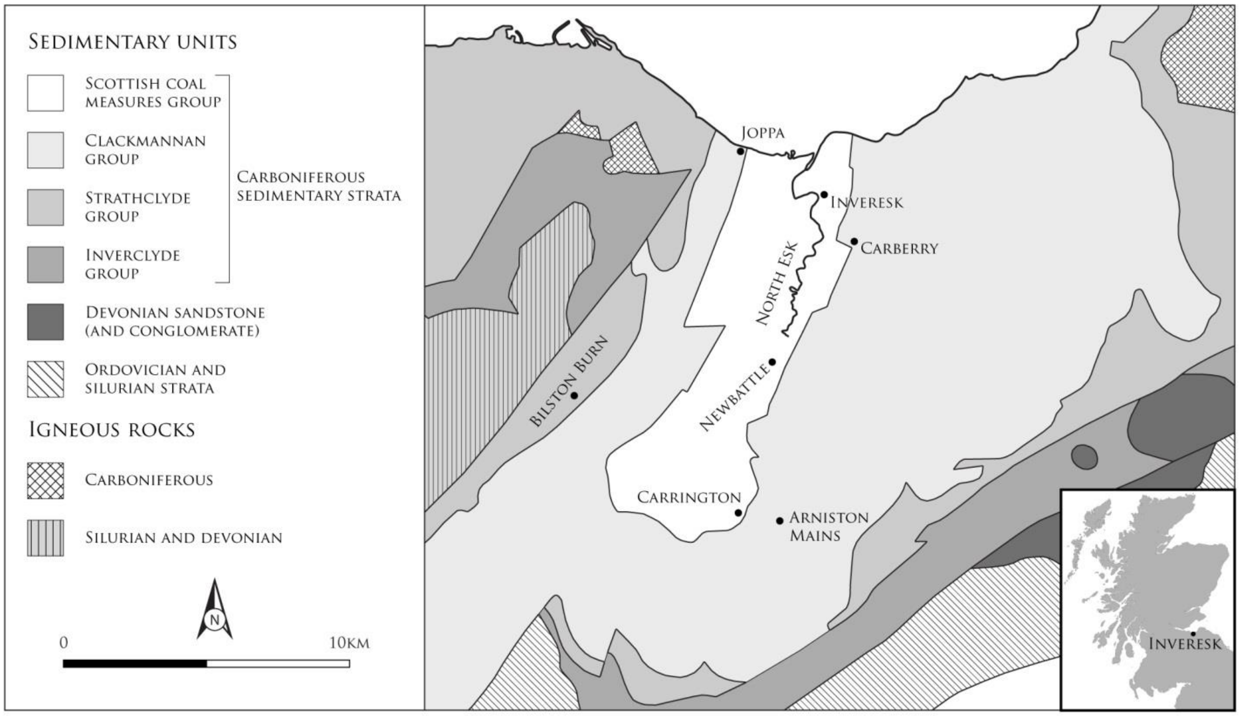
ONLINE FIG. 54b. Photomicrograph of thin section of altar base in cross-polarised light. Scale bar: 5 mm. (*Photos: F. McGibbon*)



ONLINE FIG. 55a. Photomicrograph of thin section of Sol altar in plane-polarised light. Scale bar 10 mm.

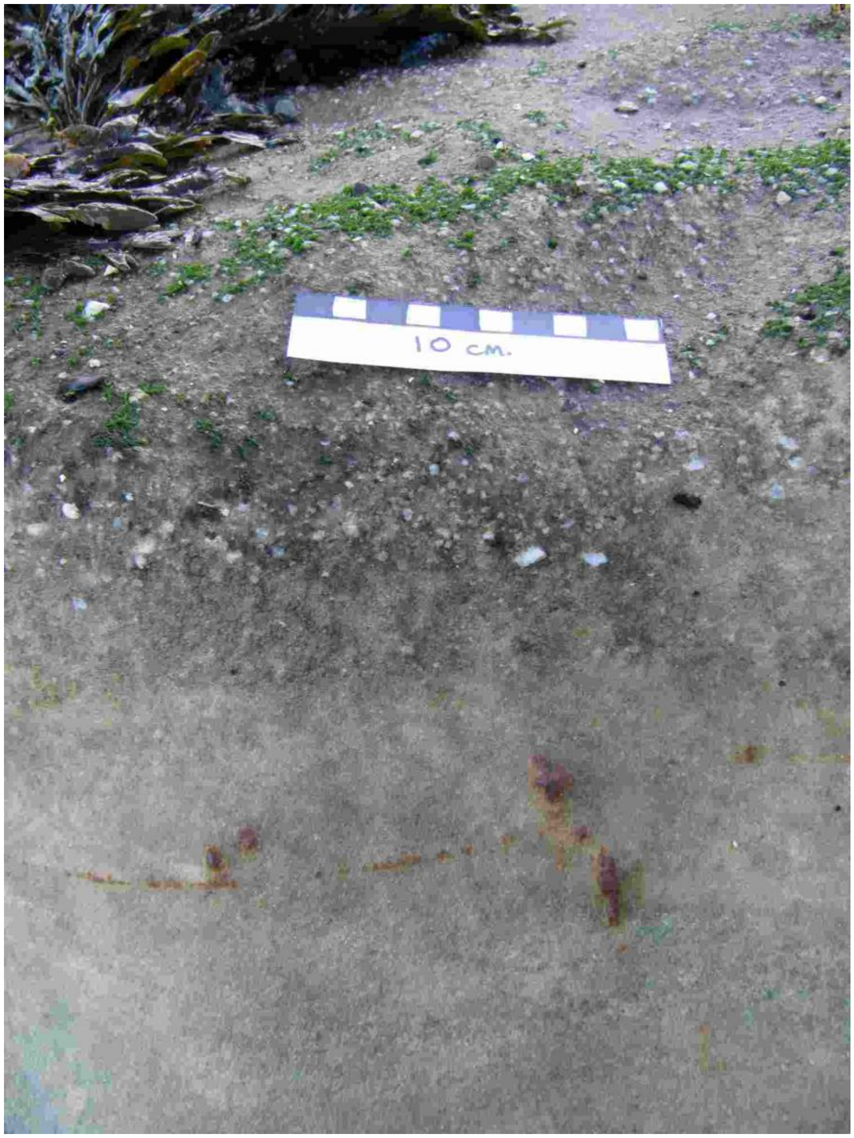


ONLINE FIG. 55b. Photomicrograph of thin section of Sol altar in cross-polarised light. Scale bar 10 mm.
(*Photos: F. McGibbon*)



ONLINE FIG. 56. Outline geological map of the Midlothian coalfield. The rocks at Joppa are in the Passage Formation which is part of the Clackmannan Group. (*Drawing: Jamie Humble / AOC*)

ONLINE FIG. 57. Bleached white sandstone beneath dark grey seatearth at Joppa shore (NT 320 734). Dark material on top of sandstone is modern seaweed debris and sea coal fragments. Sandstone is wet in this image, and so darker than when dry. Scale: 10 cm. (*Photo: F. McGibbon*)



ONLINE FIG. 58. Detail of sandstone at Joppa shore (NT 320 734). 10 cm scale sits on coarser-grained upper part of sandstone bed and includes angular clasts of milky quartz. The lower part of the bed is uniformly finer-grained and shows secondary iron deposits on a bedding plane and also as nodules. (*Photo: F. McGibbon*)

ONLINE FIG. 59. Bleached sandstone at Joppa shore (NT320 734) showing secondary iron staining in leisegang rings. Field of view is 20 cm. (*Photo: F. McGibbon*)

APPENDIX 4: ANALYSIS OF RED AND WHITE PIGMENTS FROM THE INVERESK PARK ALTARS

By RUTH SIDDALL

Visible paint traces (red and white) on the two altars were sampled for investigation of their nature. This report outlines the detailed methodology and results; conclusions can be found in the main text.

Sample locations are described in Table 3 and illustrated on ONLINE FIGS 60–1. Samples were taken from the edges of paint patches using a scalpel and transferred into glycerine pill capsules for storage. Paint layers were very thin, the paint being applied directly to the stone of the monuments without a base layer or ground. Consequently, where possible two samples were taken of each paint colour from different parts of the paint scheme on the altars. Sampling of colours is alternated, which enables the analyst to identify contamination from previous samples. Only one patch of paint was available on the Mithras altar, so both samples were taken from the same location.

Table 3. Sample details

# 1	Sol altar: red paint from band below inscription, taken from beneath the letter A of FLA, 10.5 cm from the 'Winter' edge of the altar.
# 2	Sol altar: white paint from the inscription, taken from the cross-bar of the letter A in CAS, 27 cm from the 'Winter' edge of the altar.
# 3	Sol altar: red paint from the band below the inscription, taken from beneath the letter C of SOLI.C, 17.5 cm from the 'Spring' edge of the altar.
# 4	Sol altar: white from the lower serif on the second letter C of SOLIC C, 22 cm from the 'Spring' edge of the altar.
# 5	Mithras altar capital: red paint taken from the central bud of the floret.

SAMPLE ANALYSIS

The primary identification technique used was optical polarising light microscopy (PLM). This technique is routinely used in mineralogy and petrology for the study of rocks and mineral phases and is therefore well suited to the identification of archaeological pigments, which are often minerals or the synthetic analogues of minerals. PLM provides *primafacie* evidence of the colour of pigment phases used, which in turn gives evidence of technological choices such as colour mixing to vary the hue of paints. It also allows identification of different polymorphs of phases used, i.e. iron oxides from ore deposits or iron oxides from earth deposits, providing information on provenance of materials. Particle size and shape can also reveal a wealth of information concerning pigment manufacture, either in the form of processing of natural pigments or the chemical methodology used in the manufacture of synthetic phases. It is also possible to characterise many organic-based pigments, derived from plant and animal dyes using PLM, especially with the use of UV microscopy and macroscopic examination. However, further analytical techniques are used for more secure identifications.[13]

[13] Eastaugh *et al*. 2004b; Silva *et al*. 2006.

Minute samples, *c.* 0.5 mm^3, are required for analysis and characterisation of pigments using grain dispersions in PLM. Samples are collected with a scalpel from the edges of pigmented areas, usually from areas where there is already damage. These are not prepared in any way before mounting (i.e. they are not ground or washed), so as not to lose any features which may relate to the manufacture of the pigment.

The presence of lead in white pigments (i.e. white lead carbonate and related pigments) can be analysed using a standard test. A few grains of pigment are placed in a petri dish and a drop of 10 per cent acetic acid is added. If the sample fizzes, carbonate is present. A small crystal of potassium iodide is then added to the sample. If lead is present an instant and obvious reaction to form bright yellow lead iodide occurs.

Samples are mounted as grain dispersions on glass microscope slides in MeltMount™ and protected by a glass cover slip. These slides can subsequently be used for analysis using both PLM, reflected light microscopy (for the identification of opaque phases) and UV microscopy. If required, the slides are also suitable for use for Raman microspectroscopy. This latter technique is routinely used in the analysis of pigments, but it is not an ideal technique for the analysis of natural ochres since spectra of reliable quality for the identification of phases are rarely produced.

Optical analysis was carried out on a LeitzOrthoplan-Pol microscope with a maximum optimum magnification of 1000x. Observations were made in both plane-polarised light (PPL) and under crossed-polars (XPL). Phases are identified via a set of characterised optical properties routinely used in the identification of minerals in thin section[14] and of cultural materials including pigments.[15] Reference collections comprising samples from securely provenanced sources and of known composition are also used for comparison of particles observed (see below).

ANALYSIS OF THE SAMPLES: SOL ALTAR

 # 1 Red

The main colouring component of the pigment is red iron oxide, hematite (see ONLINE FIG. 62 upper). This is in an earthy, ochreous form composed of 1–2 µm particles and aggregates of these. Such particles are at the resolution of the optical microscope and are typical of fine iron oxides. In PPL, these particles are coloured orange-red. Under crossed-polars, they exhibit high birefringence masked by the strong body colour of the minerals and appear a bright cherry-red colour. A few hematite-coated grains of quartz are also present, which would have been derived from the geological source of the ochre. Also present is ‘clean’ quartz, with no iron oxides adhering to the grains, derived from the sandstone substrate of the altar.

#2 White

Due to the thin and worn paint layer, a very small sample of the white paint was obtained in this sample and it cannot be considered representative of the pigment. The sample was tested for lead but no

[14] See Deer *et al*. 1992; Gribble and Hall 1992.
[15] See Eastaugh *et al*. 2004b.

reaction was observed. Much of the sample turned out to be quartz, derived from the substrate rather than pigment. There is also significant ‘contamination’ from the adjacent red pigment. This component has the appearance of sample # 3.

Traces of white pigment occurred as fine (3–5 µm length), fibrous, elongate grains, with very low birefringence and radiating extinction when observed under crossed-polars. This is a form of calcium sulphate hydrate, the mineral gypsum. However, given the particularly fine particle size of these grains, it is most likely to be burnt gypsum, i.e. plaster of Paris, also known as *gesso*.

 # 3 Red

The main colouring component of the pigment is once again red iron oxide, hematite, with optical properties as described for # 1 (above; see ONLINE FIG. 62 lower, ONLINE FIG. 63). Here the pigment is coating quartz grains as well as occurring as individual particles and aggregates of particles. Also present are hematite-coated particles of chert and feldspar. Other iron oxides and iron oxide hydroxides are present in this sample, ranging in colour from orange red to yellow. A few particles are amorphous iron oxide hydroxides. A short fragment of either cow or horse hair, 0.5 mm in length is also present in the sample (ONLINE FIG. 63)[16].

 # 4 White

In contrast to # 2 a more representative sample of the white pigment was obtained in # 4 (see ONLINE FIG. 64). The sample was tested for lead but no reaction was observed. The main colouring agent is bone white in particles of size 25–35 µm. This pigment occurs as low relief, low birefringence, colourless particles with a distinctive pitted surface. This was an excellent match for a modern preparation of bone white made from beef bones (see below; RS518).

A component of crushed, angular quartz shards showing conchoidal fracture at grain boundaries is present. This has been mechanically crushed and these grain shapes are not formed by geological process. It is non-iron coated, ‘clean’ colourless chalk. It could either have been added as a filler or used to aid the grinding of the bone white.

Also present is abundant red pigment as described in # 1 and 3 above; this includes iron-oxide (hematite)-coated, rounded quartz grains, and rare particles of chert and muscovite mica, of 0.1 mm grain size. Aggregates of finely crystalline hematite are also abundant. Minor charcoal, probably derived from the soil is also present.

ANALYSIS OF THE SAMPLES: MITHRAS ALTAR

 # 5 (1 and 2)

Two samples taken from the orange-red paint on the Mithras altar are of identical composition (see ONLINE FIG. 65). The colouring component is a mixture of both red and yellow iron oxide and oxide

[16] A note on fibres: fibres of various kinds are often seen in dispersion samples and these are generally contamination from the clothing of workers and are distinct as cotton wool or synthetic, often dyed fibres. Animal hairs (other than wool) and plant fibres may be contamination from the excavation or may otherwise be diagnostic of the environment of a painted object. They may also represent hairs from paint brushes.

hydroxide minerals; primarily goethite and hematite. Amorphous flakes of orange iron oxides (ferrihydrite) are also present. There are abundant, rounded iron oxide-coated quartz grains, up to 0.2 mm diameter. Clay is also a significant component of this pigment in clumps and crumb-like polycrystalline aggregates with moderate birefringence. Particles vary in size from a few microns to 50 µm. In some cases these are a very bright yellow, with particulate iron oxide finely disseminated amongst the clay particles. There is a very small amount of madder pink pigment present in the form of dyed, crushed calcite grains. Some charcoal is also present, probably as a contaminant from the soil.

COMPARATIVE REFERENCE SAMPLES

Comparative reference samples, of known composition and provenance were used to compare some of the phases seen in the samples analysed from the Inveresk altars pigments. Their use is for comparison of optical properties and these samples should *not* be interpreted as potential sources for the pigments identified in this report. The samples were from collections owned by Ruth Siddall (prefixed RS) and the Pigmentum Project (prefixed P).

P1382 Roman madder lake from the House of the Painter, Pompeii. Cat. Pompeii 18107.[17]

RS181: Red ochre, Hangman's Lodge Ironstone from Ribblesdale UK. Pip Seymour Pigments.

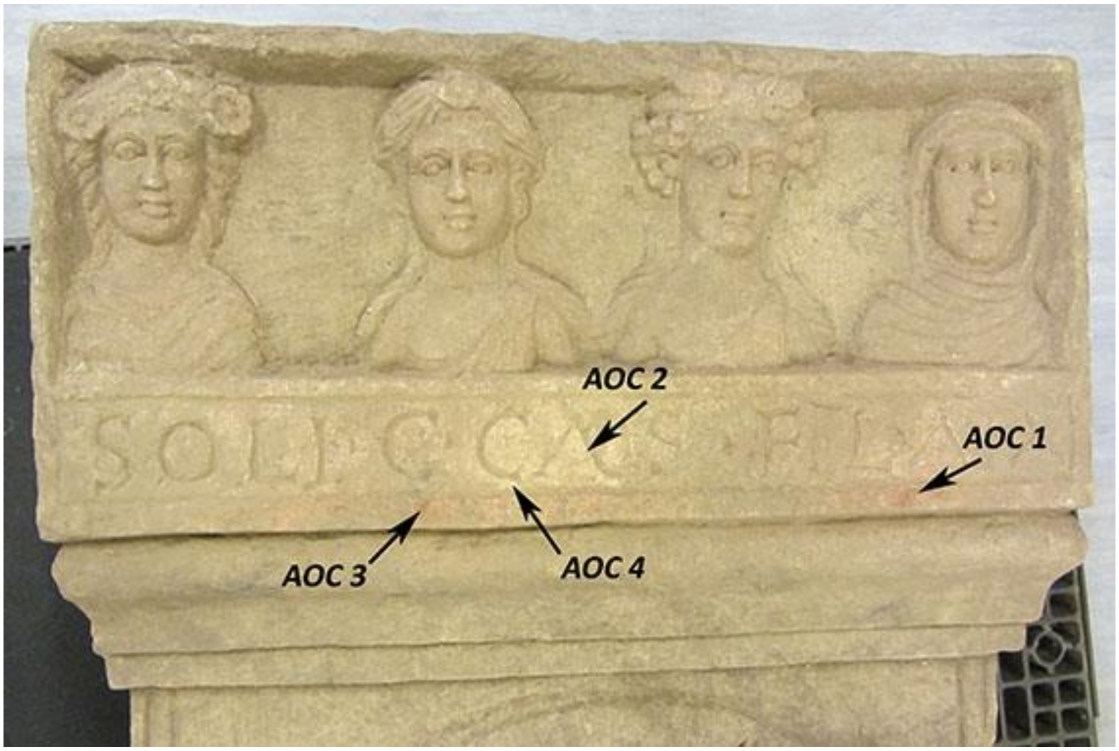
RS193: Bright red ochre, Clearwell Caves, Forest of Dean. Colllected by Onya McCausland, 2011.

RS501: Shotover yellow clay ochre from Monks Farm, Risinghurst, Oxfordshire; Whitchurch Sandstone Formation. Collected by Ruth Siddall and Onya McCausland, 2012.

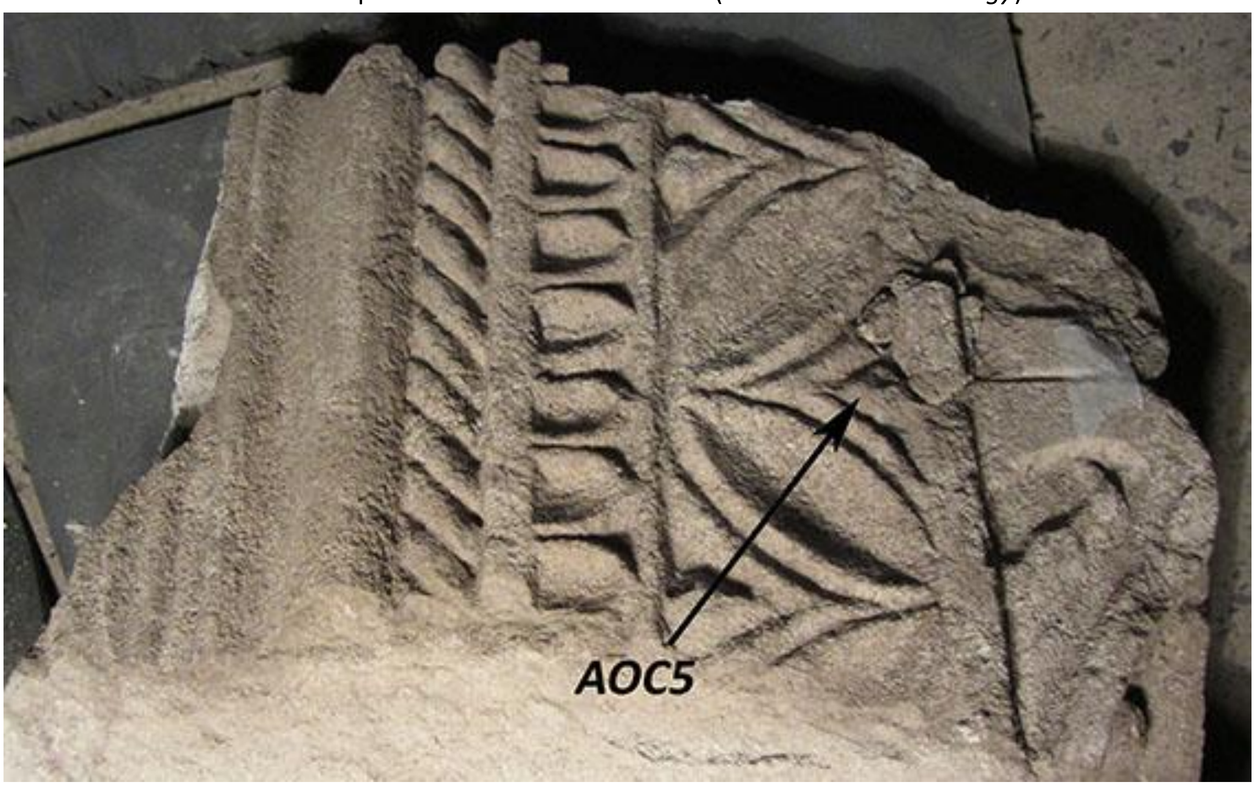
RS504: Red ferrihydrite ochre from Deerplay Moor, Lancashire. Coal Authority acid mine drainage settling lagoons. Collected by Ruth Siddall and Onya McCausland with the permission of Joe Bartram, Coal Authority, 2012.

RS519: Bone White made by Jo Volley from beef bone, 2012, for the installation *White Bone Black* UCL Slade School of Fine Art.

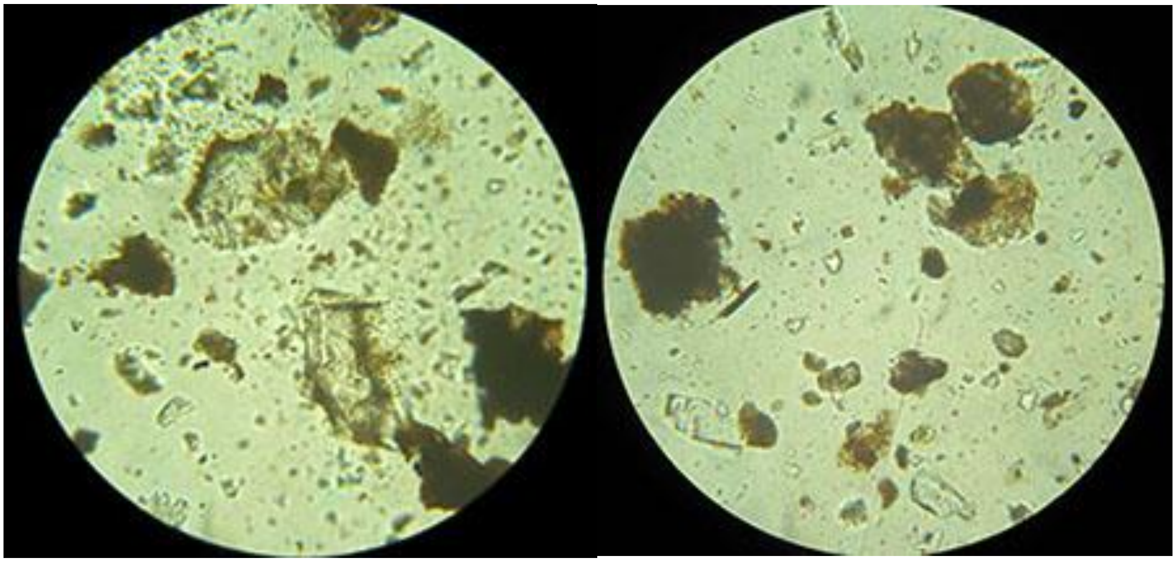
[17] Walsh *et al*. 2003.



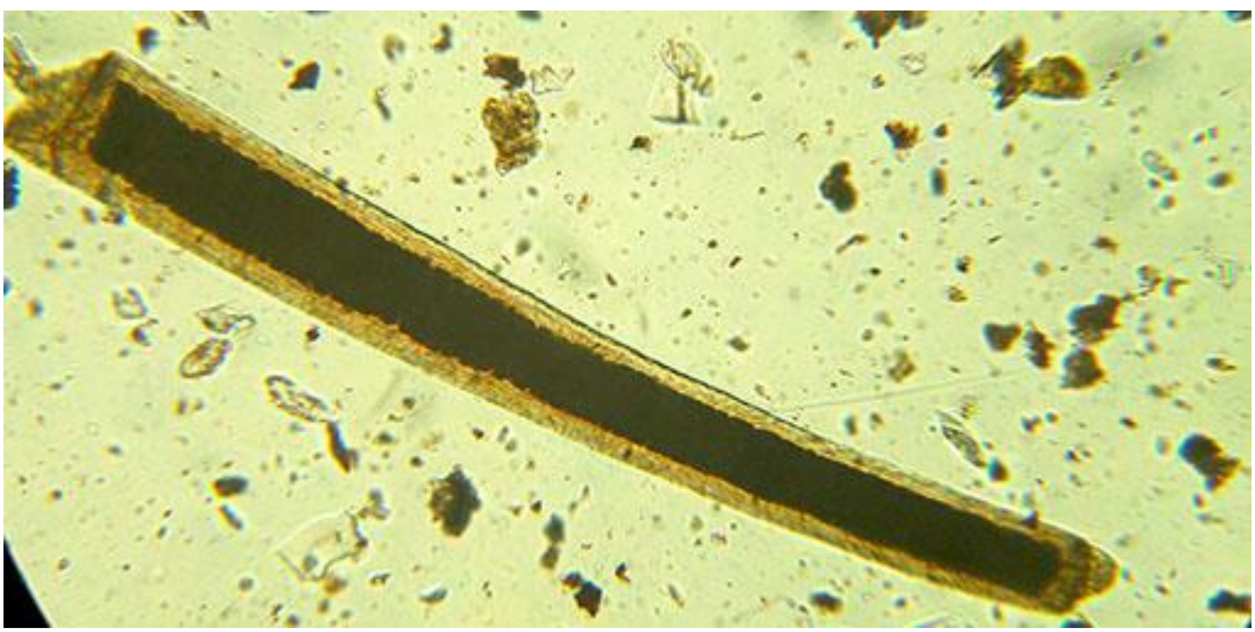
ONLINE FIG. 60. Sample locations for the Sol altar. (*Photo: AOC Archaeology*)



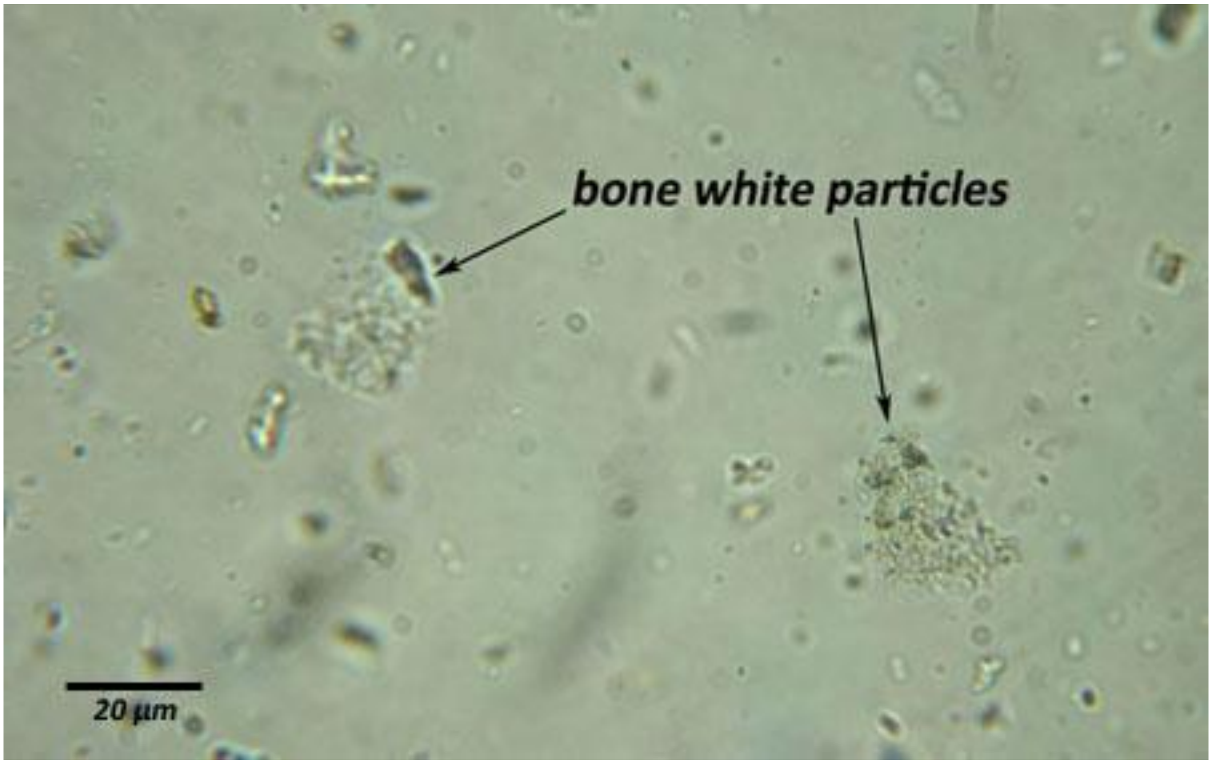
ONLINE FIG. 61. Sample location for the Mithras altar. (*Photo: AOC Archaeology*)



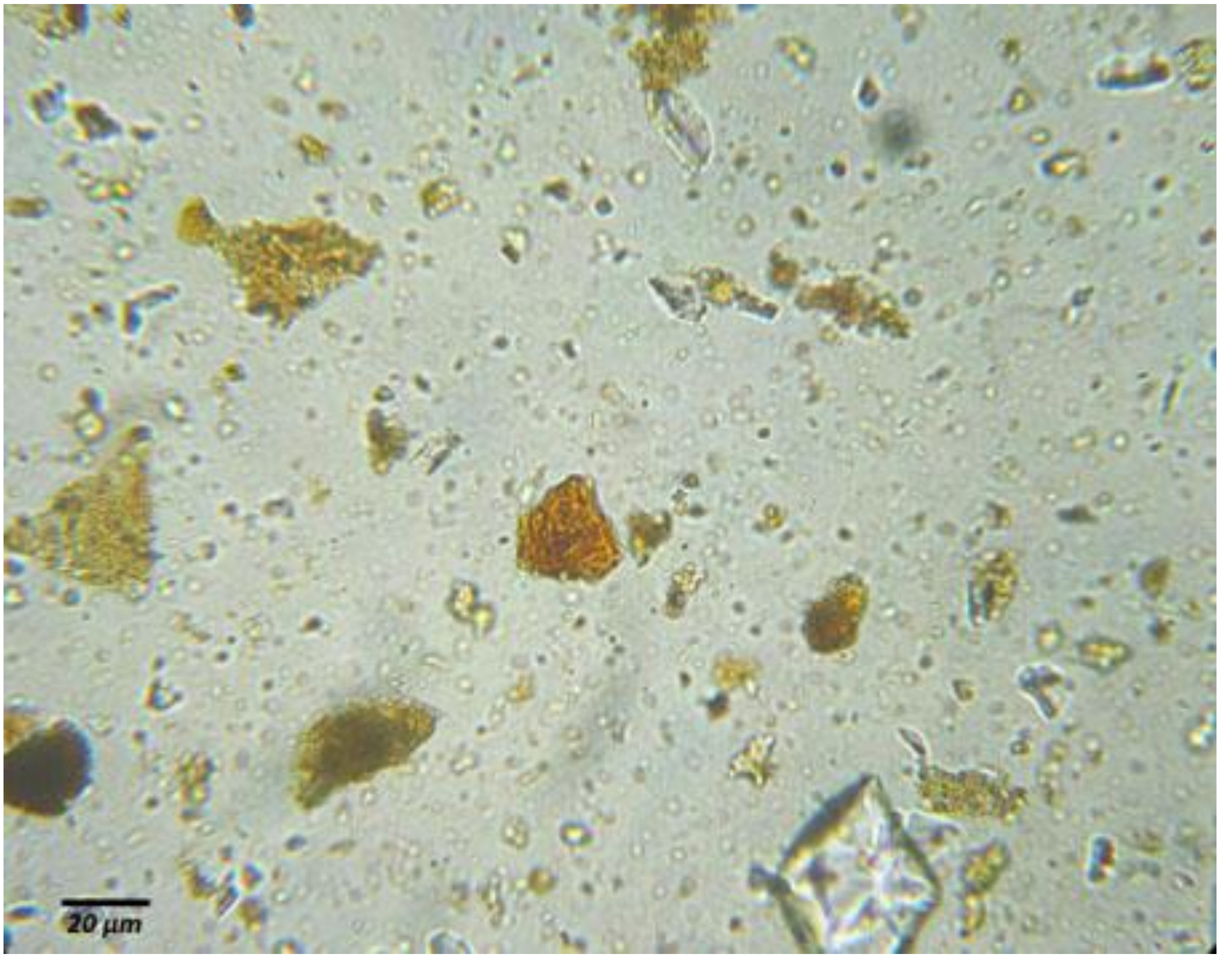
ONLINE FIG. 62. Images of the red paint from the Sol altar. Left: general view of # 1 showing red iron oxide particles present as granular aggregates and coating quartz grains. Right: general view of # 3, showing it to be of the same composition as # 1. Both images taken at 400x magnification; the field of view is *c.* 0.3 mm. (*Photo: R. Siddall*)



ONLINE FIG. 63. Sol altar, red paint sample # 3. A fragment of cow or horse hair within the pigment which may have been derived from the artist's brush. The image was taken at 250x magnification and the field of view is 0.6 mm. (*Photo: R. Siddall*)



ONLINE FIG. 64. # 4 Sol altar; white paint. Particles of bone white. Taken at 400x magnification. (*Photo: R. Siddall*)



ONLINE FIG. 65. # 5 Mithras altar; red-orange paint. General view of sample # 5 (1). Particles of yellow and orange iron oxides. The large lozenge-shaped particle at the bottom right is quartz.
Taken at 400x magnification. (*Photo: R. Siddall*)

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